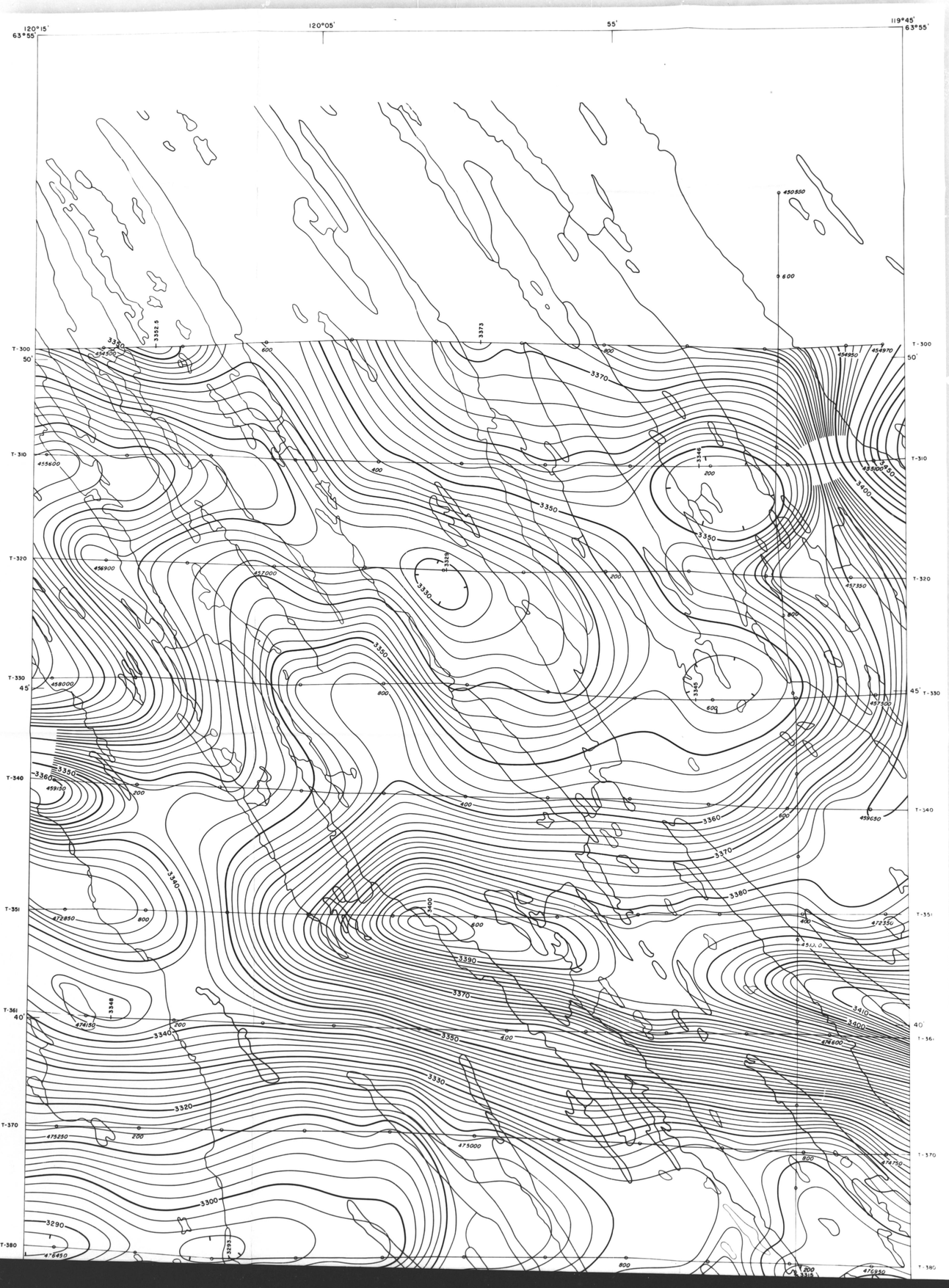

120°15'
63°55'
120°05'
55'
119°45'
63°55'
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AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

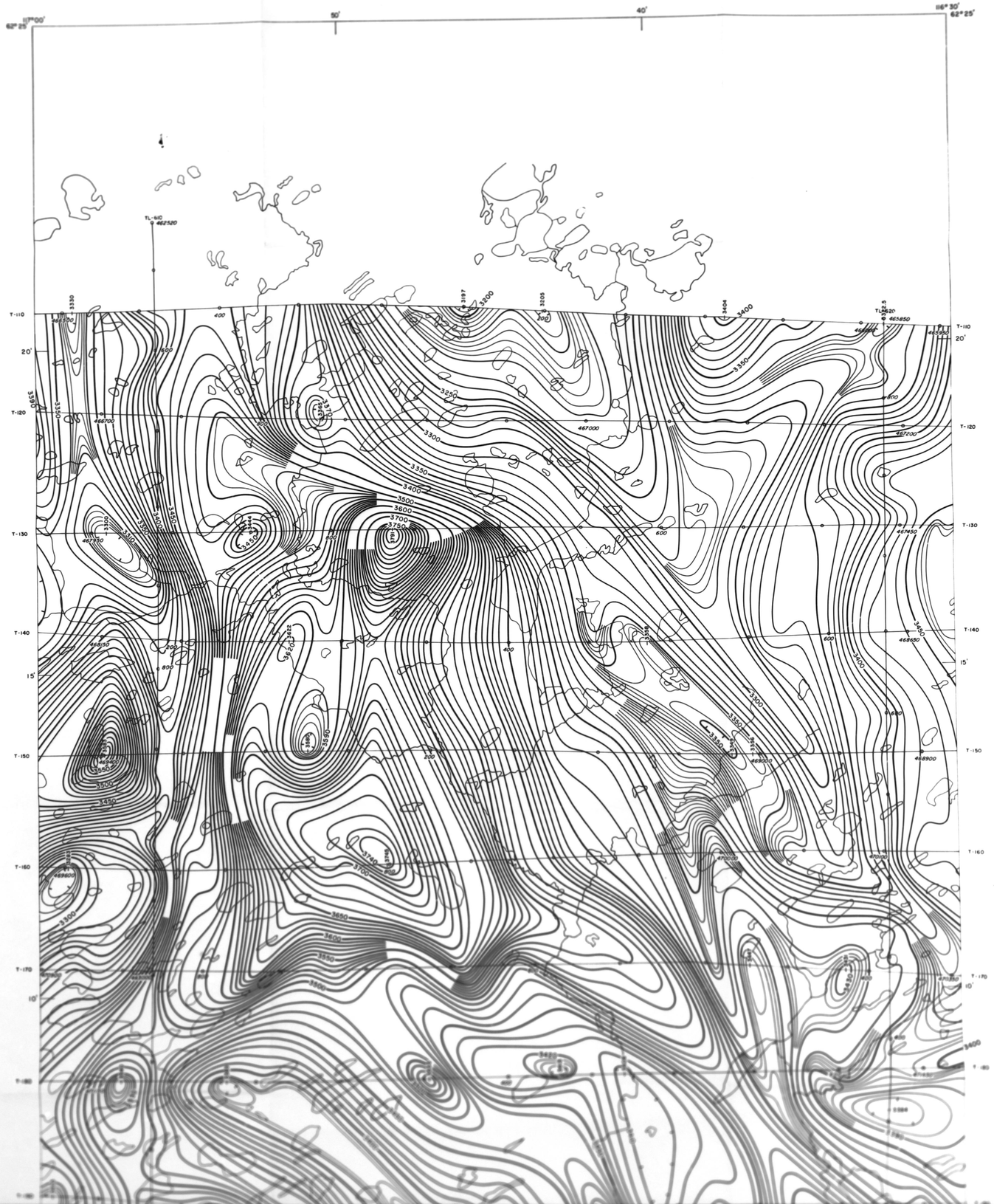
SCALE 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

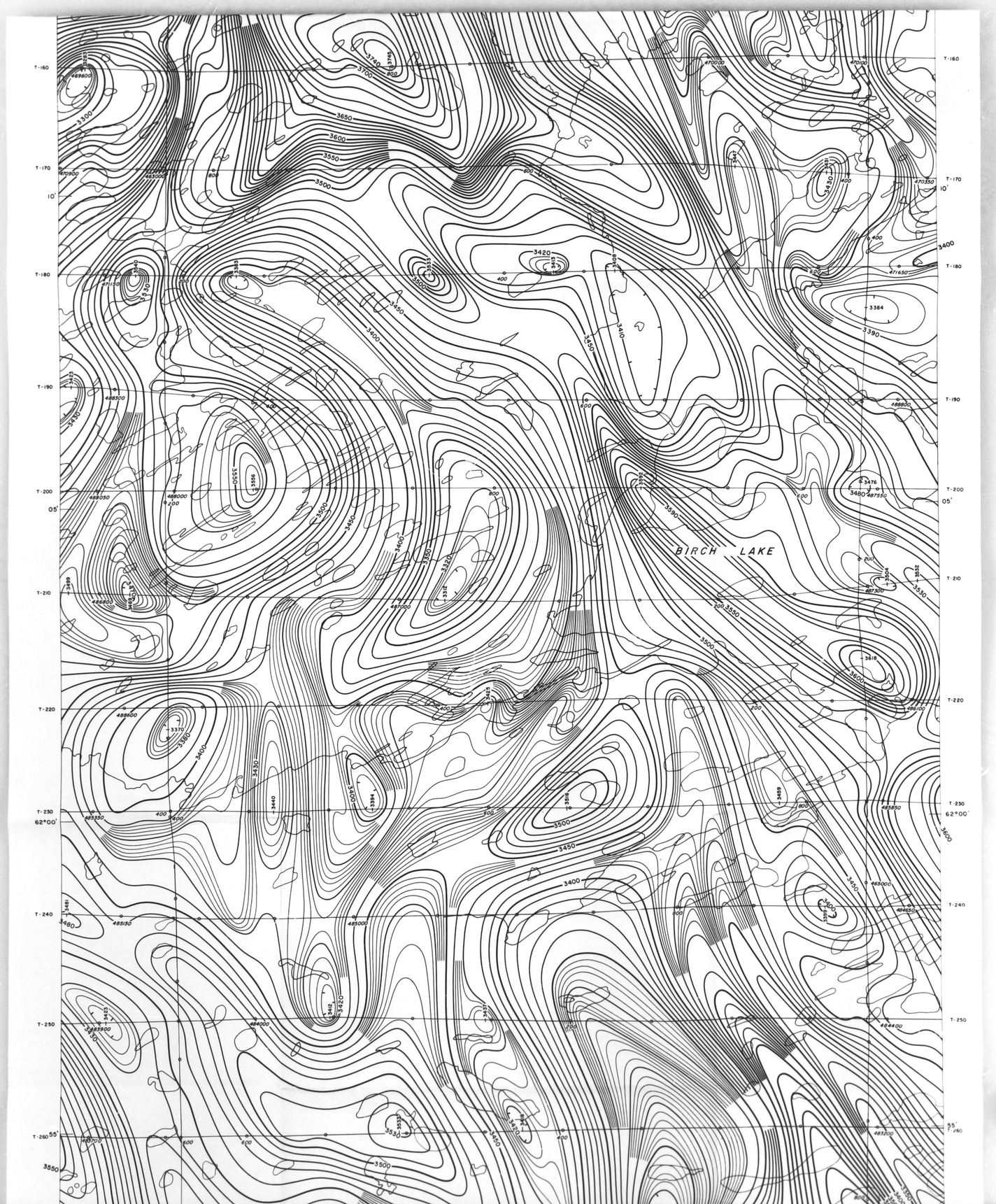
NORMAL VARIATION	
CORRECTION APPLIED	
HORIZONTAL CONTROL	BASED ON 1:250,000 TOPOGRAPHICAL MAPS PUBLISHED BY D.E.M.R. OTTAWA
FLIGHT ALTITUDE	2600 FEET A.S.L.
TRAVERSE INTERVAL	2 MILES
CONTOUR INTERVAL	20 GAMMA
BASE INTENSITY	ARBITRARY

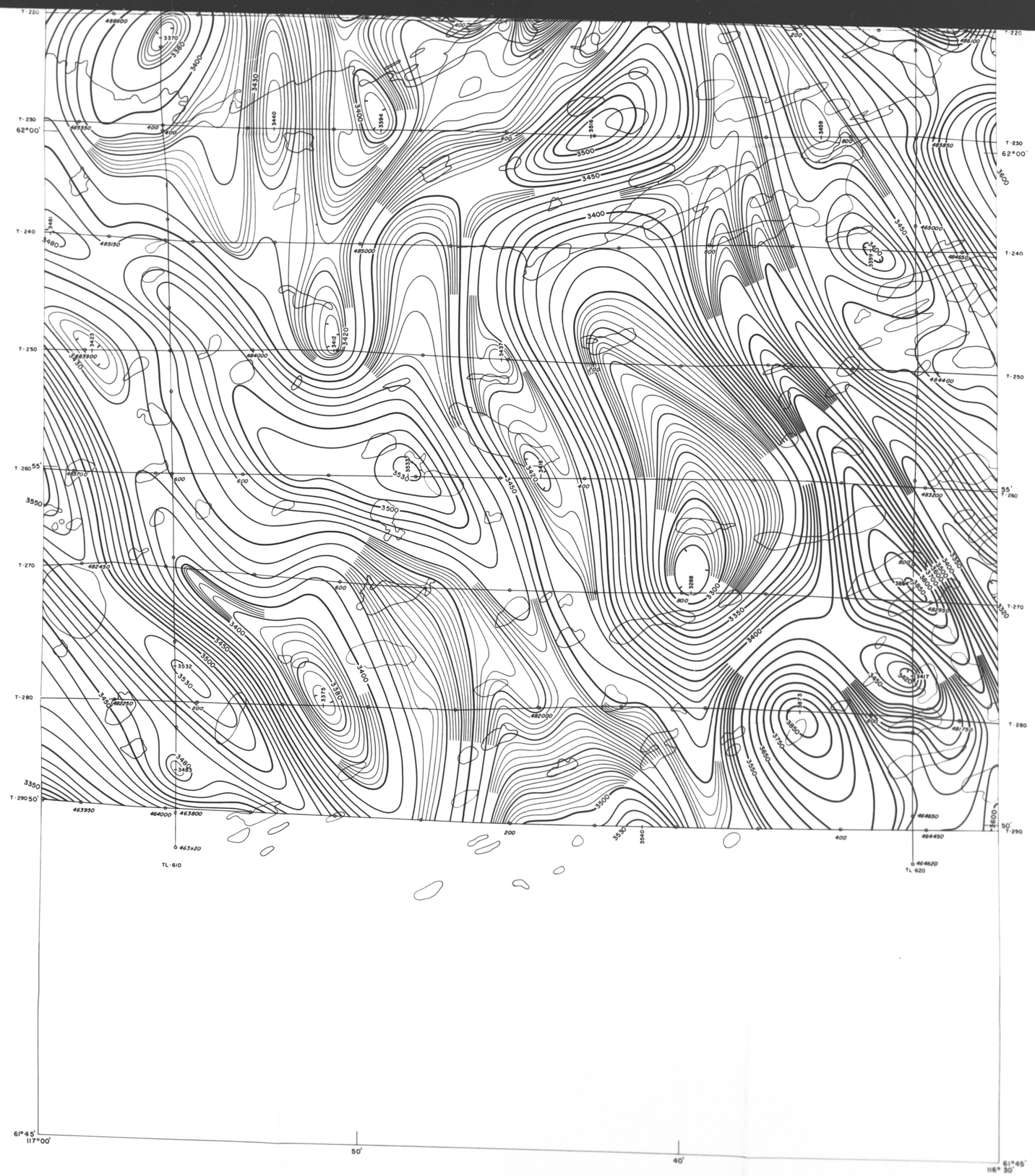
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

2 OF 2


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62° 25'
50'
40'
116° 30'
62° 25'
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T-120
T-130
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AIRBORNE MAGNETOMETER SURVEY

RAE LAKE AREA

NWT

RAYALTA PETROLEUMS LIMITED

SCALE- 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

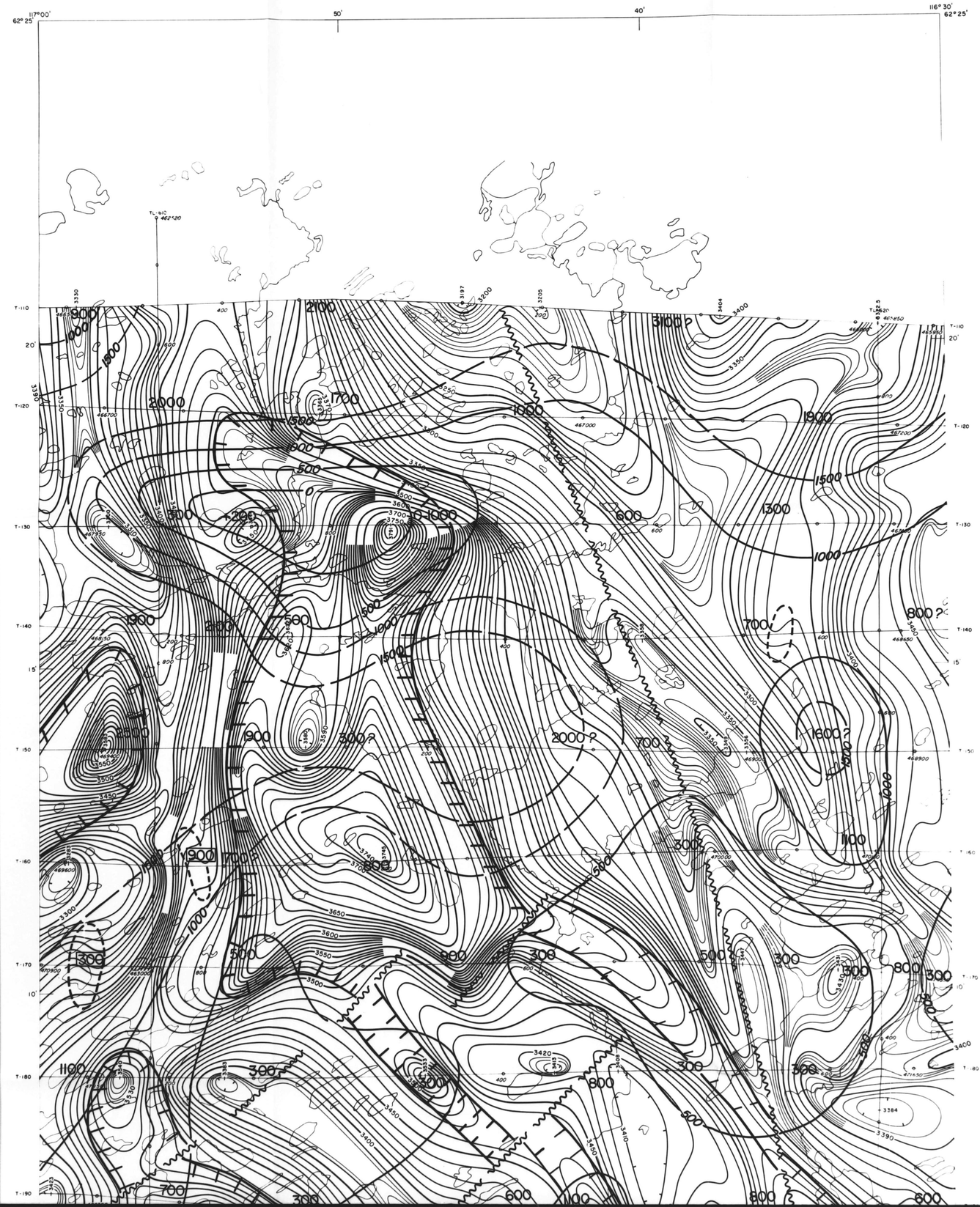
NORMAL VARIATION
CORRECTION APPLIED

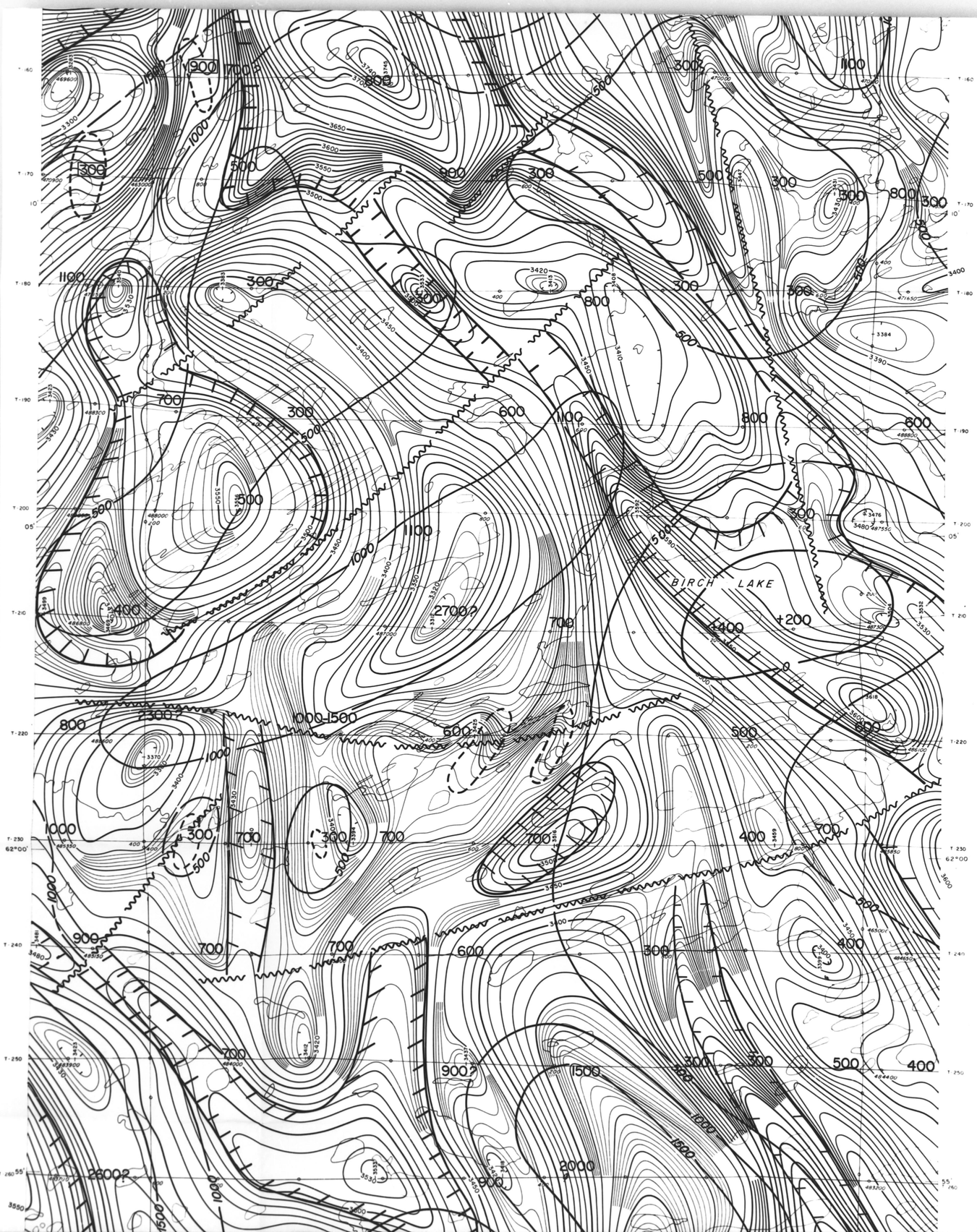
HORIZONTAL CONTROL . . . . . BASED ON
1-250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA

FLIGHT ALTITUDE	2000 FEET A.S.L.
TRAVERSE INTERVAL	2 MILES
CONTOUR INTERVAL	25 GAMMAS
BASE INTENSITY	ARBITRARY

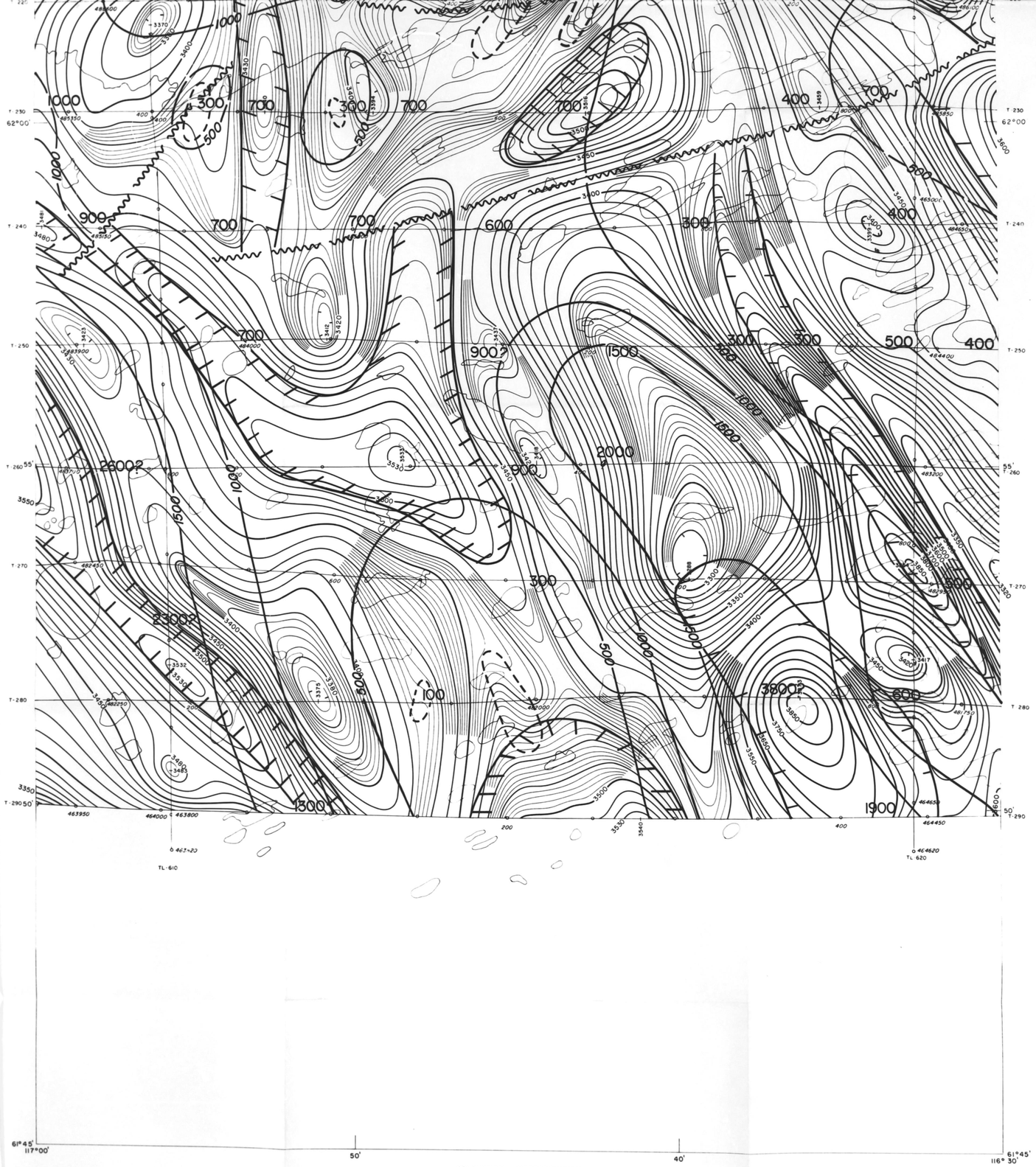
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

CAS 9058


117°00'
62°25'
50'
40'
116°30'
62°25'
T-110
T-120
T-130
T-140
T-150
T-160
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20'
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BIRCH LAKE
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GEOPHYSICAL INTERPRETATION
OF
AIRBORNE MAGNETOMETER SURVEY
RAE LAKE AREA
N.W.T.
RAYALTA PETROLEUMS LIMITED

SCALE 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

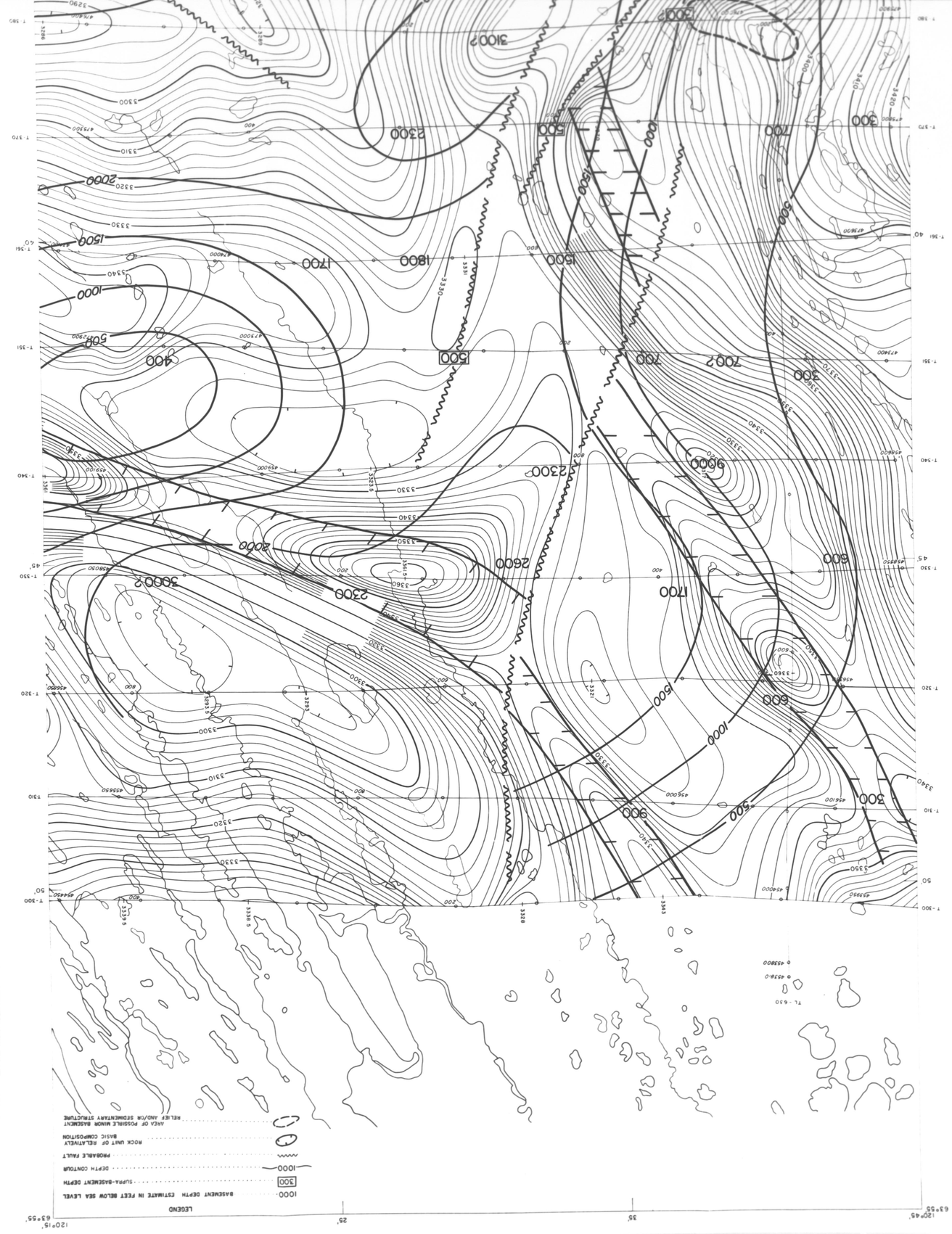
NORMAL VARIATION CORRECTION APPLIED

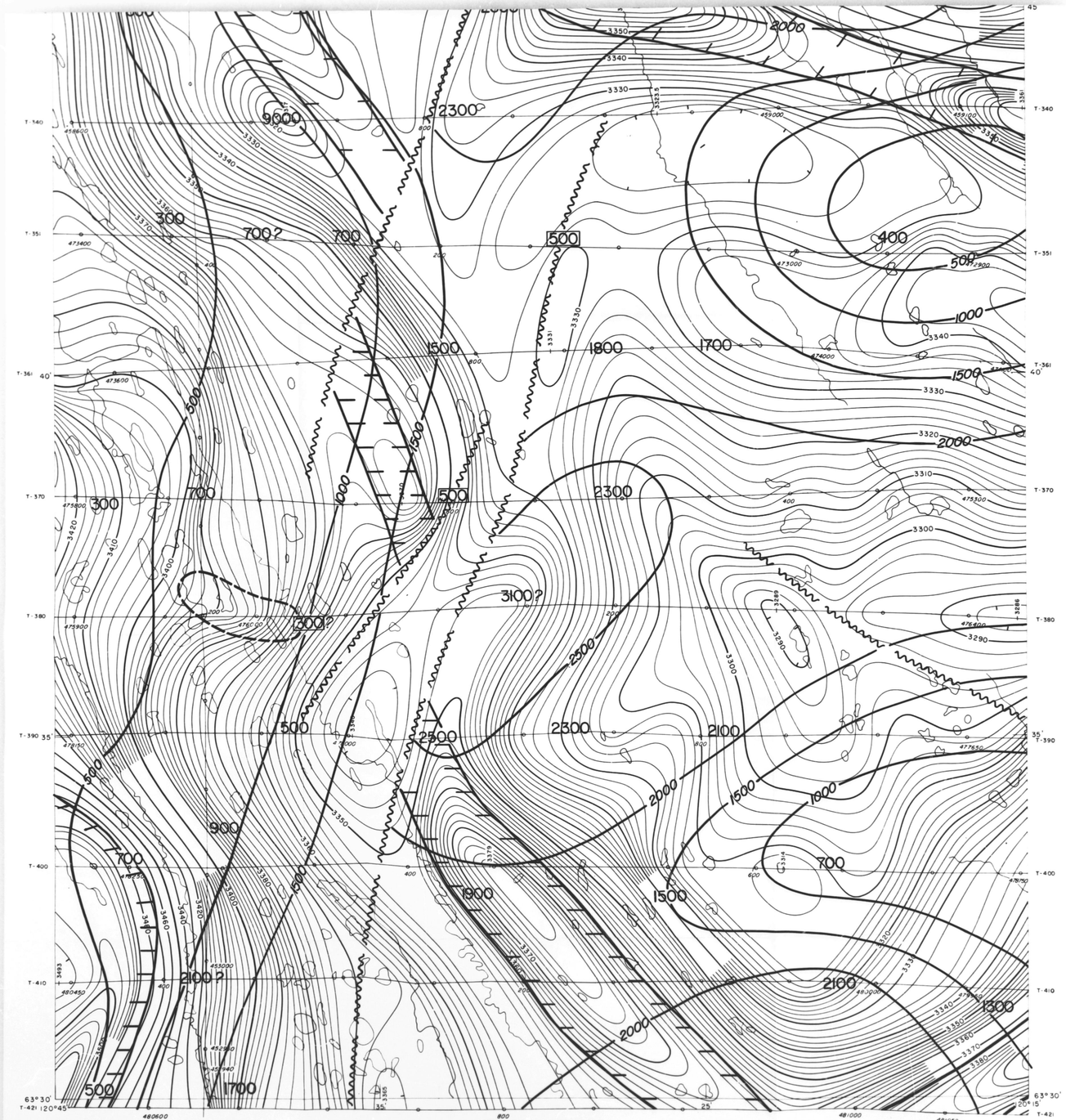
HORIZONTAL CONTROL BASED ON 1:250,000 TOPOGRAPHICAL MAPS PUBLISHED BY D.E.M.R. OTTAWA

FLIGHT ALTITUDE 2000 FEET A.S.L.
TRAVERSE INTERVAL 2 MILES
CONTOUR INTERVAL 2 GAMMA
BASE INTENSITY ARBITRARY

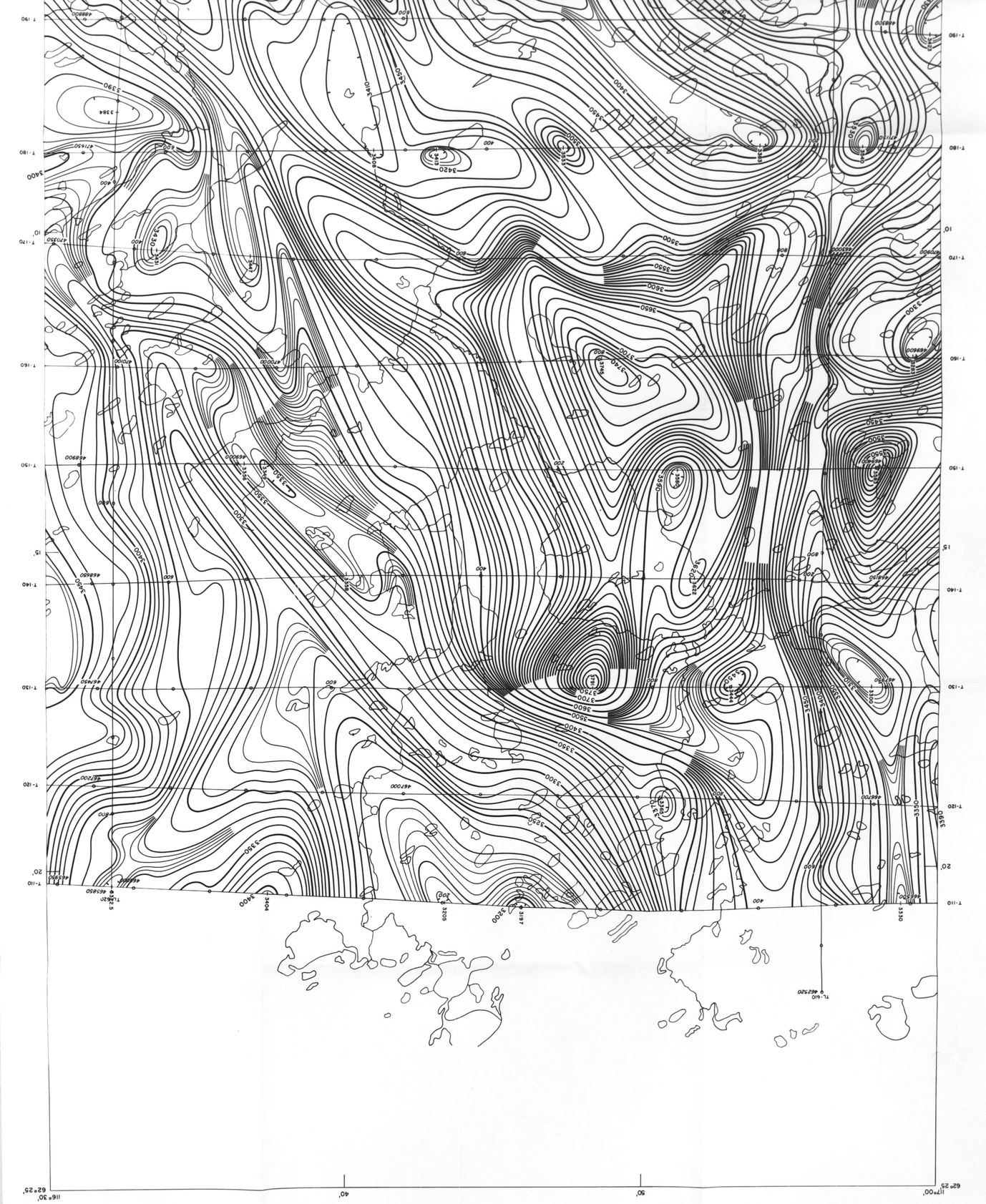
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

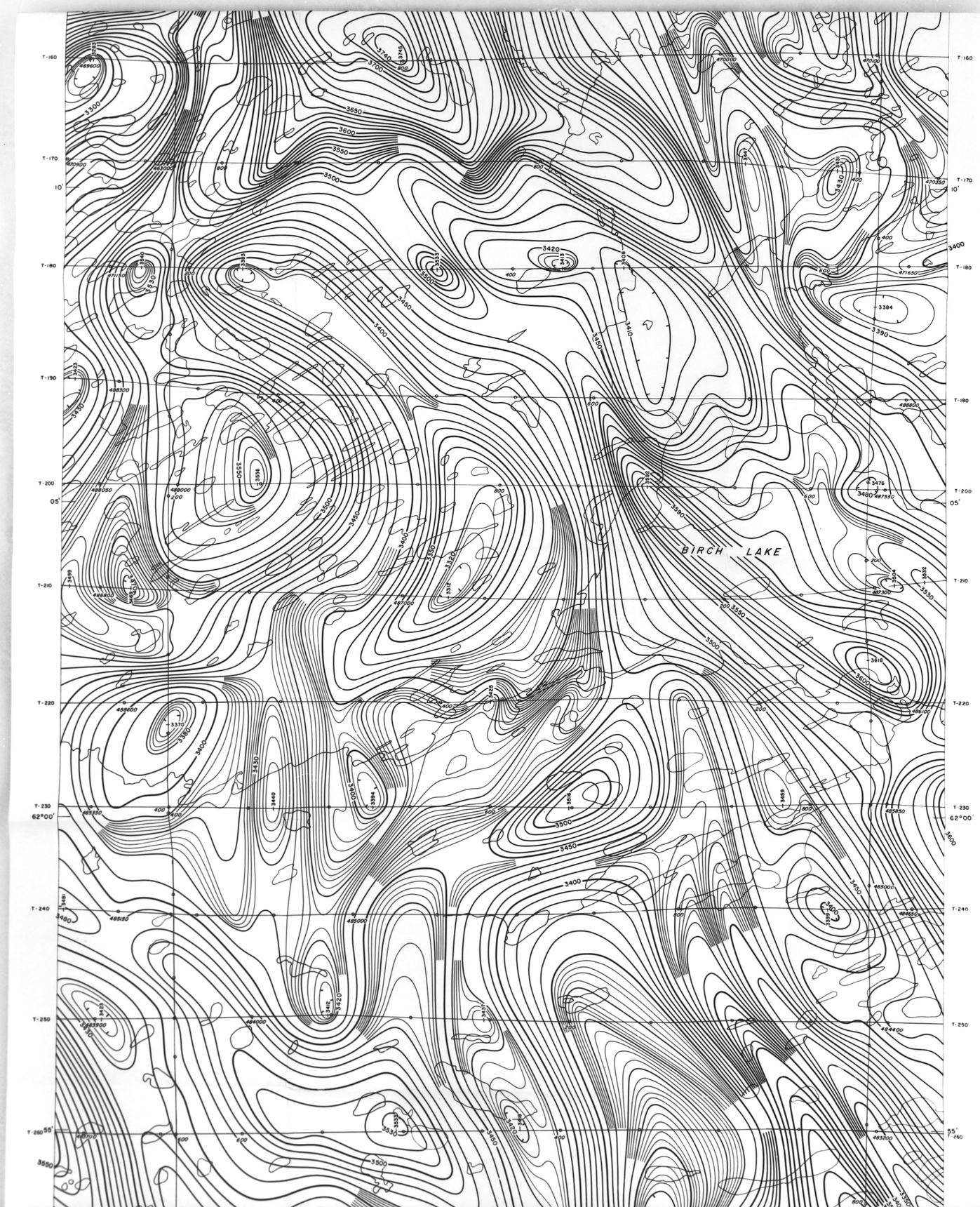
CAS. 9508


LEGEND
1000 BASEMENT DEPTH ESTIMATE IN FEET BELOW SEA LEVEL
300 SUPRA-BASEMENT DEPTH
1000 DEPTH CONTOUR
PROBABLE FAULT
ROCK UNIT OF RELATIVELY BASIC COMPOSITION
AREA OF POSSIBLE MINOR BASEMENT RELIEF AND/OR SEDIMENTARY STRUCTURE
120°15'
63°55'
120°45'
63°55'
25'
35'
45'
50'
T-300
T-310
T-320
T-330
T-340
T-351
T-361
T-370
T-380
T-390
T.L. 630
1 of


GEOPHYSICAL INTERPRETATION
OF
AIRBORNE MAGNETOMETER SURVEY
KELLER LAKE AREA
N.W.T.
RAYALTA PETROLEUMS LIMITED
SCALE 1 INCH TO 4000 FEET
4000 0 4000 8000 12000 FEET
NORMAL VARIATION
CORRECTION APPLIED
HORIZONTAL CONTROL ..... BASED ON
1:250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA
FLIGHT ALTITUDE ..... 2600 FEET A.S.L.
TRAVERSE INTERVAL ..... 2 MILES
CONTOUR INTERVAL ..... 2 GAMMA
BASE INTENSITY ..... ARBITRARY
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO
T-340
T-351
T-361
T-370
T-380
T-390
T-400
T-410
T-421
63° 30'
120° 45'
20° 15'
35'
40'
45
TL-630

2 of 2


T-190
T-180
T-170
T-160
T-150
T-140
T-130
T-120
T-110
10'
15'
20'
116° 30'
40'
50'
62° 25'


T-160
T-170
10'
T-180
T-190
T-200
05'
T-210
T-220
T-230
62°00'
T-240
T-250
T-260
55'
BIRCH LAKE

2

AIRBORNE MAGNETOMETER SURVEY

RAE LAKE AREA

N.W.T

RAYALTA PETROLEUMS LIMITED

SCALE: 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

FLIGHT ALTITUDE ..... 2000 FEET A.S.L.
TRAVERSE INTERVAL ..... 2 MILES
CONTOUR INTERVAL ..... 2 GAMMA
BASE INTENSITY ..... ARBITRARY

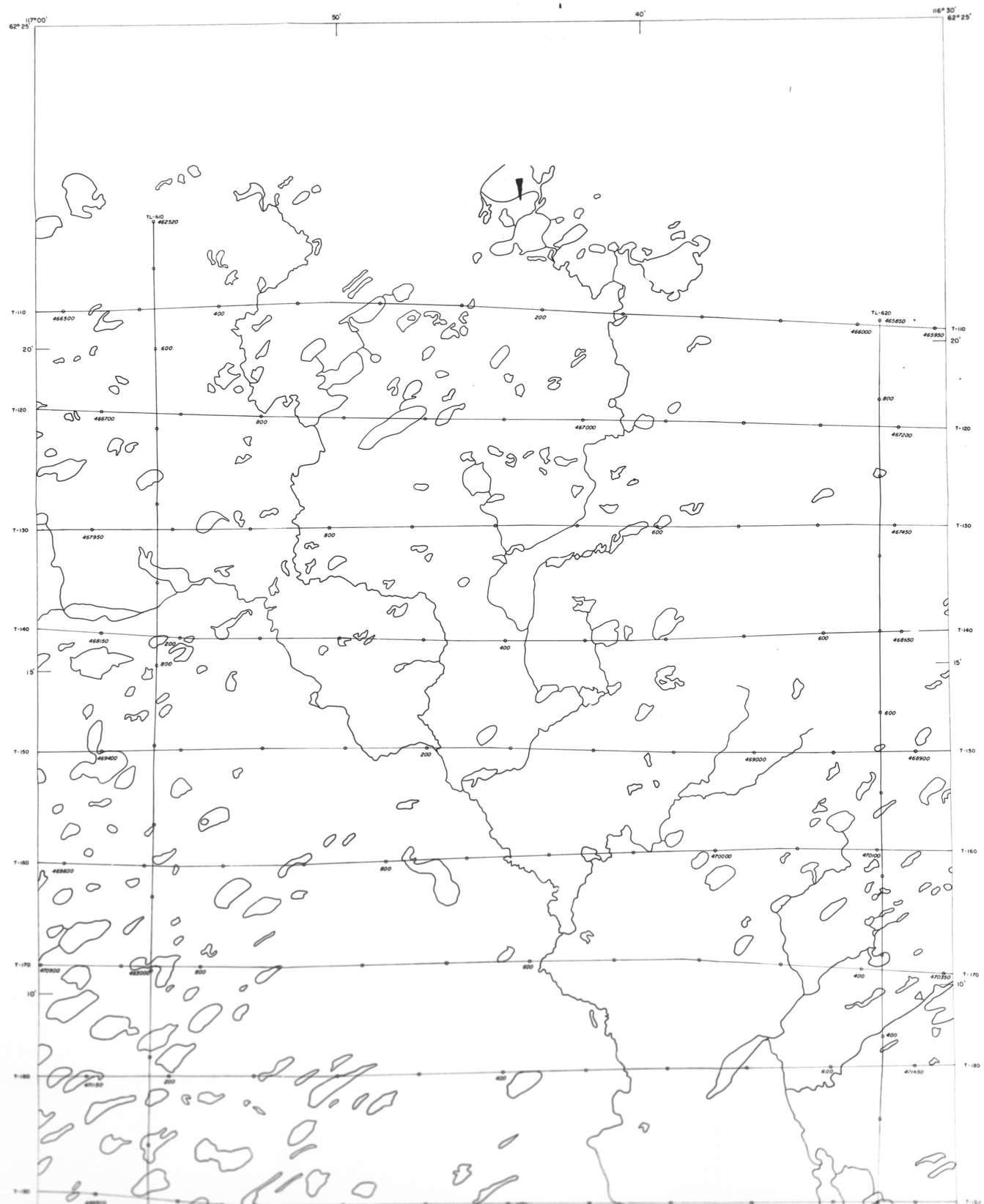
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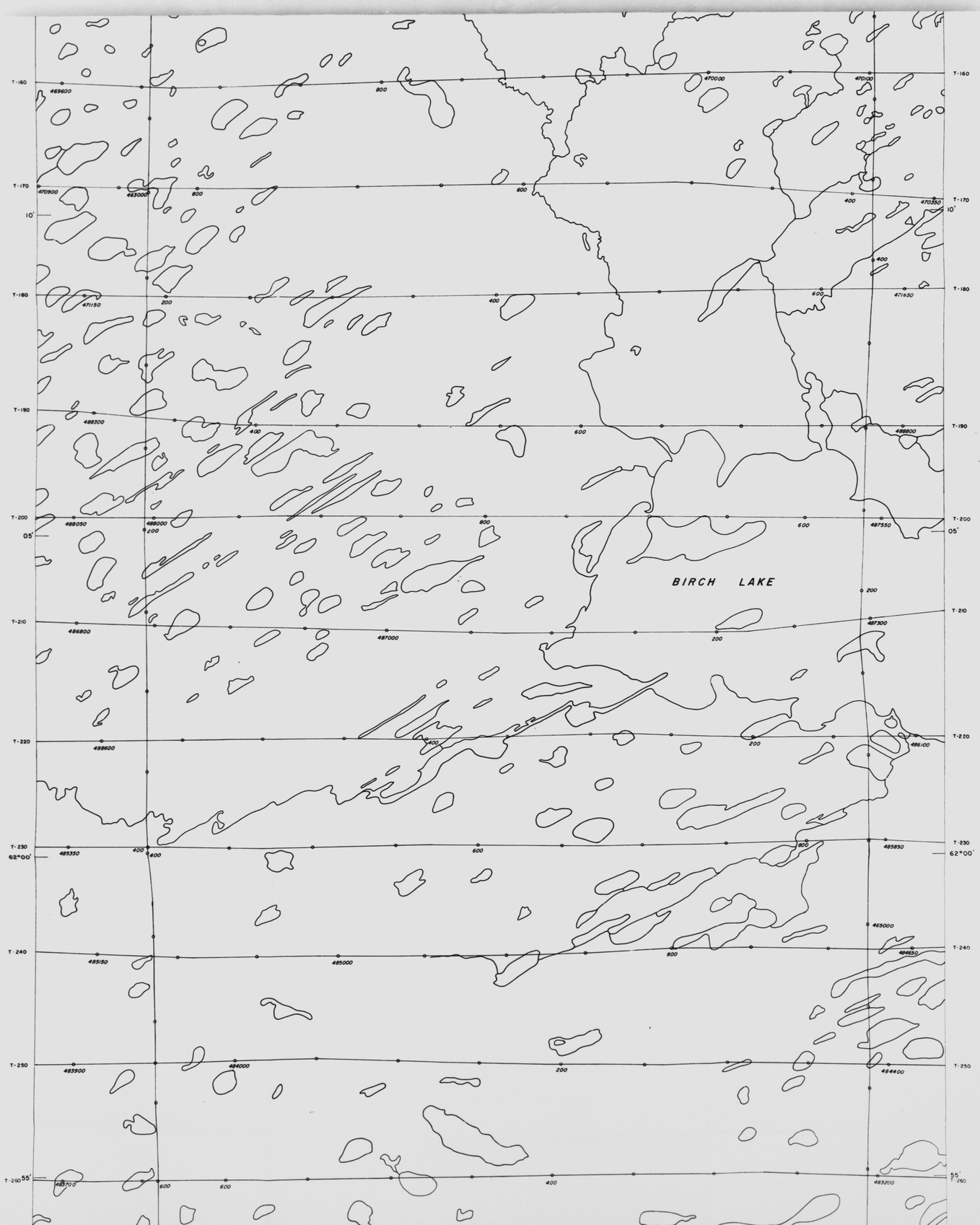
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

CAS. 9508

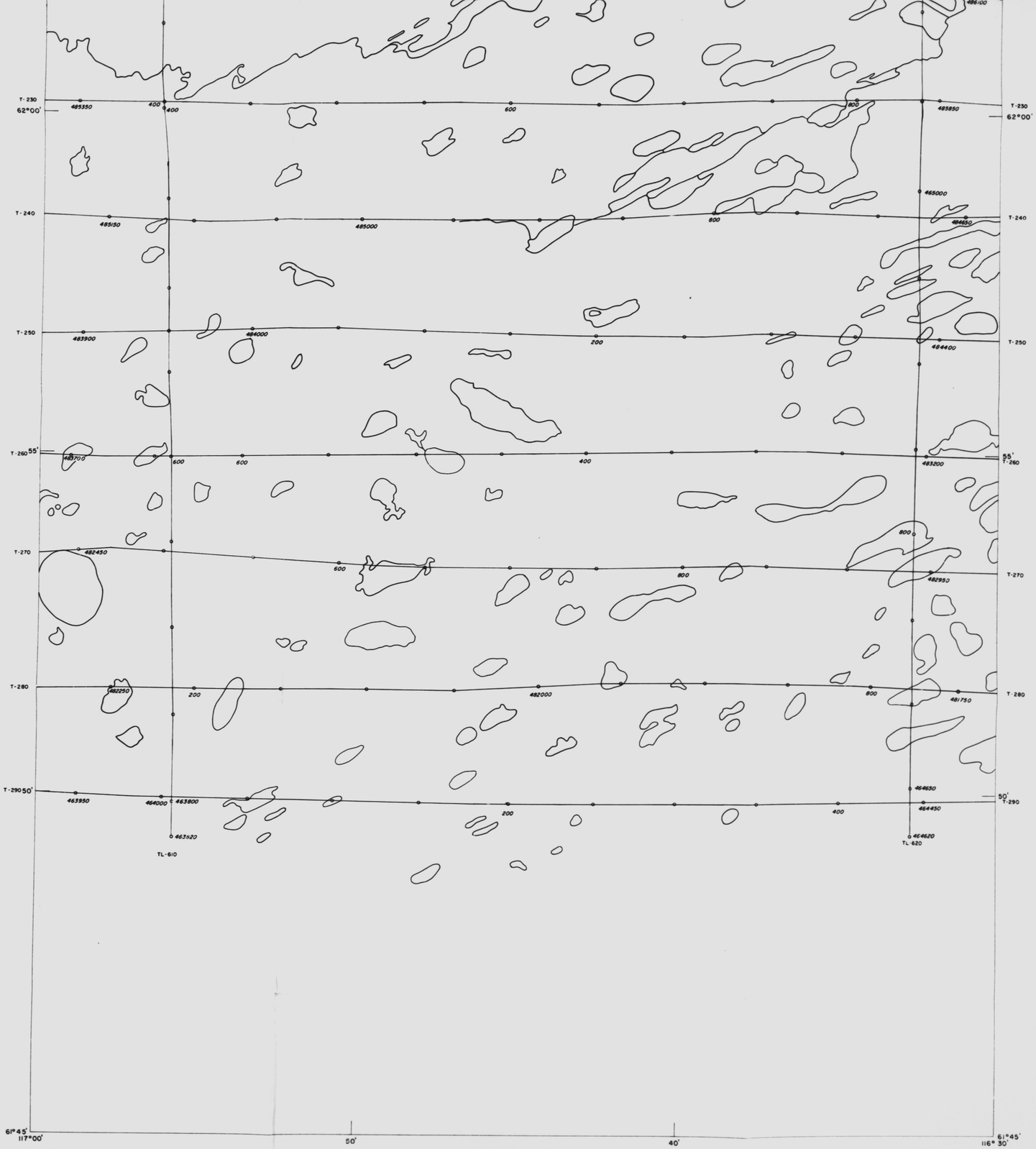
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50'
40'
116° 30'
62° 25'
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TL-620
465850
T-110
T-120
T-130
T-140
T-150
T-160
T-170
T-180
20'
15'
10'
466500
400
200
466000
465950
600
800
466700
467000
467200
467950
467450
468150
468650
469400
469000
468900
469600
470000
470100
470900
470350
471150

1 of


T-160
T-170
T-180
T-190
T-200
T-210
T-220
T-230
T-240
T-250
T-260
469600
470900
471150
488300
488050
488000
486800
487000
488600
485350
485150
485000
483900
484000
483700
470000
470100
470350
471650
488800
487550
487300
486100
485850
483200
484650
484400
463000
463000
10'
05'
62°00'
55'
BIRCH LAKE
200
400
600
800

2



AIRBORNE MAGNETOMETER SURVEY

RAE LAKE AREA

NWT

RAYALTA PETROLEUMS LIMITED

SCALE 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

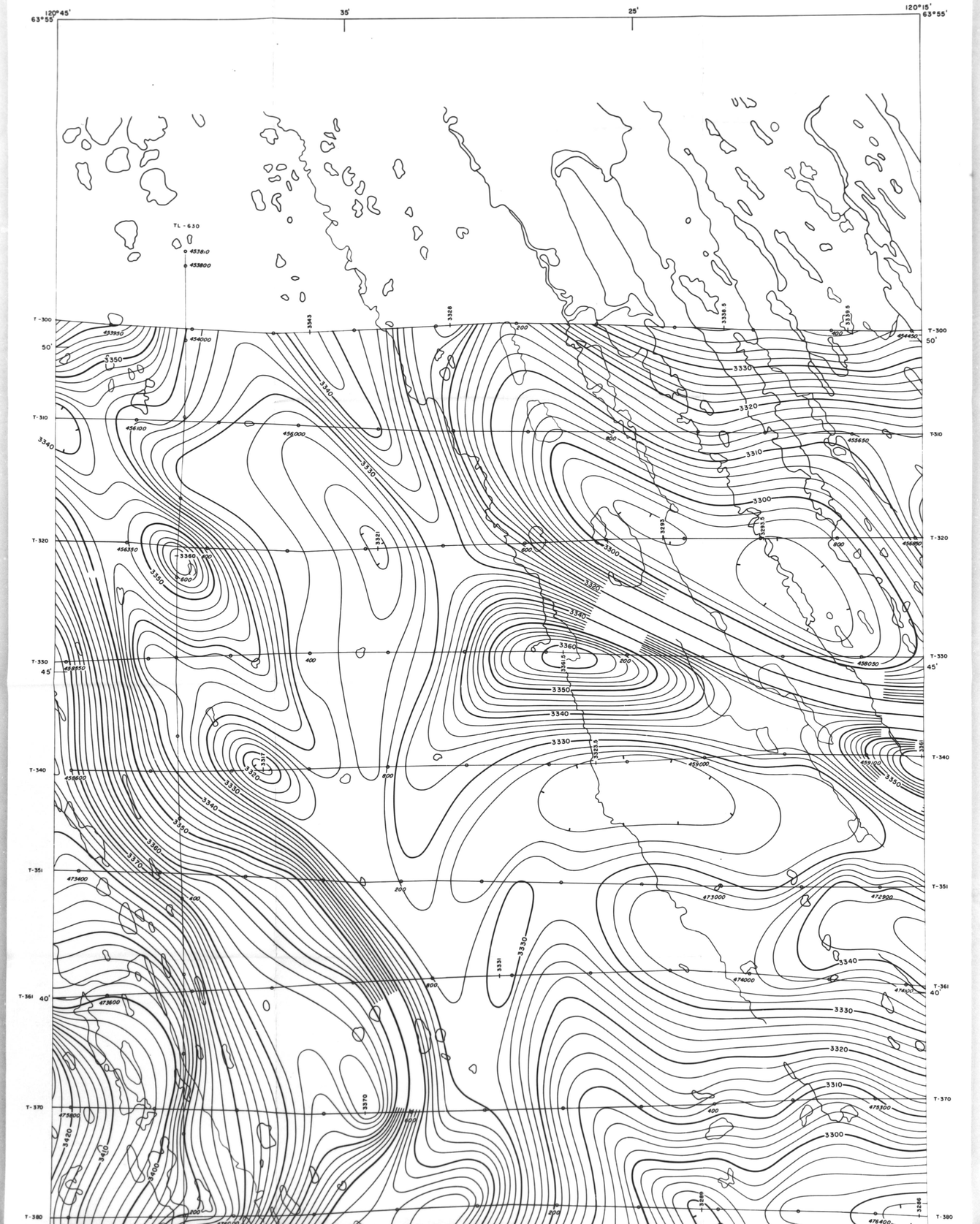
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CORRECTION APPLIED

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1:250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA

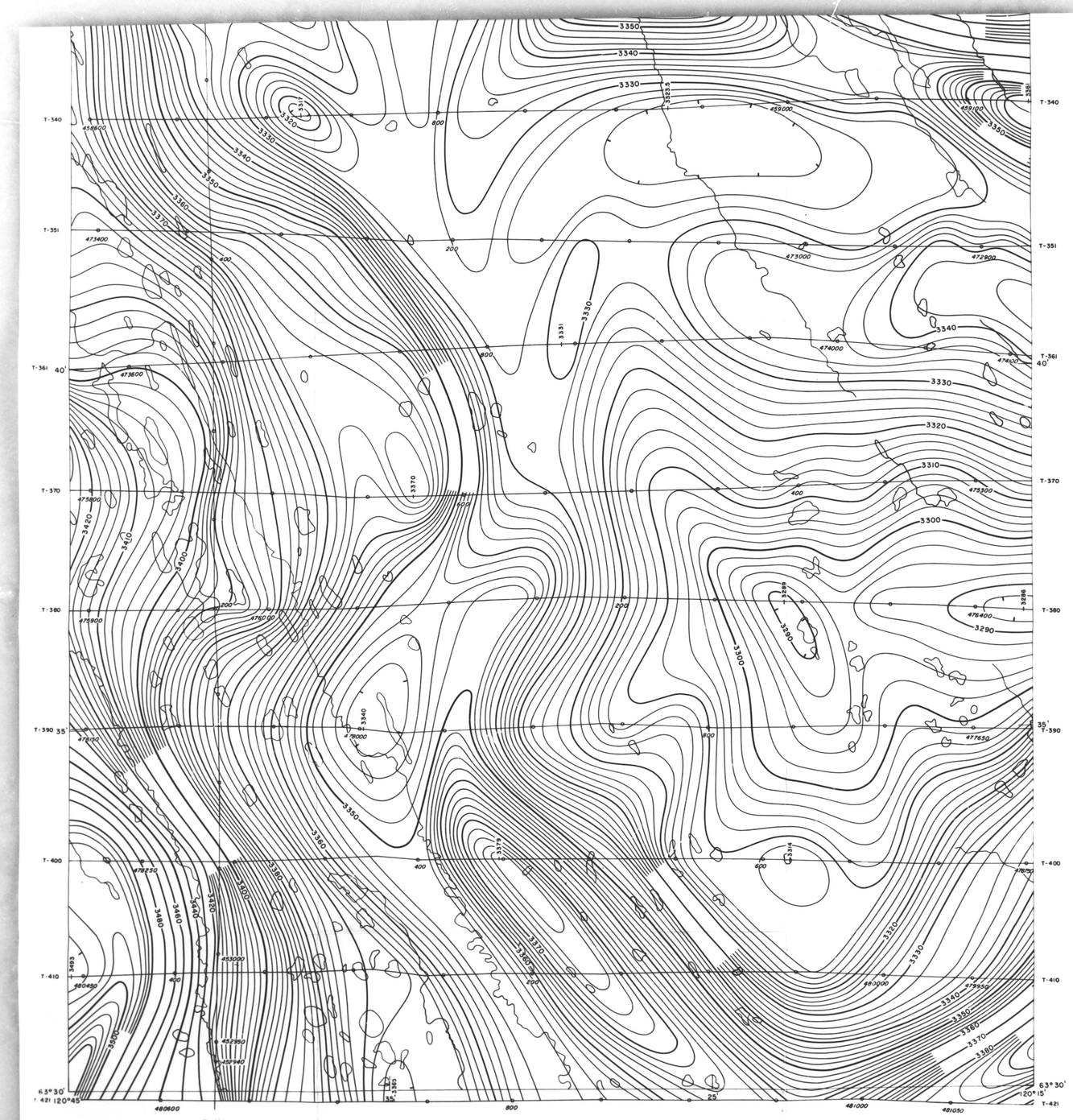
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TRAVERSE INTERVAL	2 MILES
CONTOUR INTERVAL	2 GAMMA
BASE INTENSITY	ARBITRARY

CANADIAN AERO SERVICE LIMITED
OTTAWA ONTARIO

CAS 9508


120°45'
63°55'
35'
25'
120°15'
63°55'
TL - 630
T - 300
50'
T - 310
T - 320
T - 330
45'
T - 340
T - 351
T - 361
40'
T - 370
T - 380
3340
3350
3330
3320
3310
3300
3360
3370
3380
3400
3420
456350
456100
456000
458050
458600
473400
473600
473000
474000
475800
476400

1 OF 2



AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

SCALE: 1 INCH TO 4000 FEET

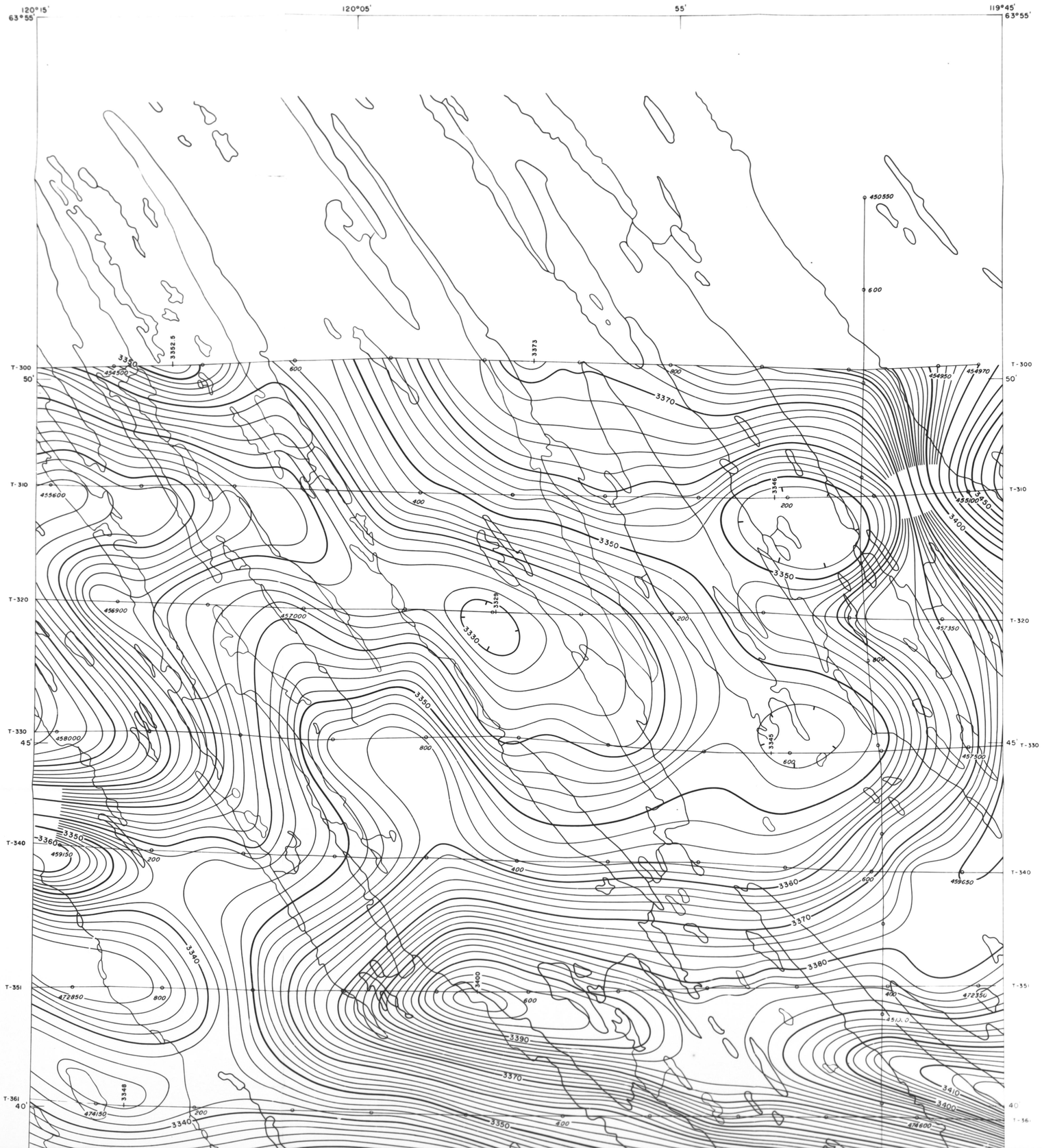
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HORIZONTAL CONTROL ..... BASED ON 1:250,000 TOPOGRAPHICAL MAPS PUBLISHED BY D.E.M.R. OTTAWA

FLIGHT ALTITUDE ..... 2600 FEET A.S.L.
TRAVERSE INTERVAL ..... 2 MILES
CONTOUR INTERVAL ..... 2 GAMMA
BASE INTENSITY ..... ARBITRARY

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO.

2 OF 2


120°15'
63°55'
120°05'
55'
119°45'
63°55'
T-300
50'
T-310
T-320
T-330
45'
T-340
T-351
T-361
40'
450550
600
454500
454950
454970
455600
456900
457000
457350
458000
457500
459150
459650
472850
472350
474150
474600
3352.5
3373
3346
3329
3345
3348
3370
3350
3330
3360
3340
3400
3380
3390
3410
200
400
600
800

1 OF 2

AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

NWT

RAYALTA PETROLEUMS LIMITED

SCALE 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

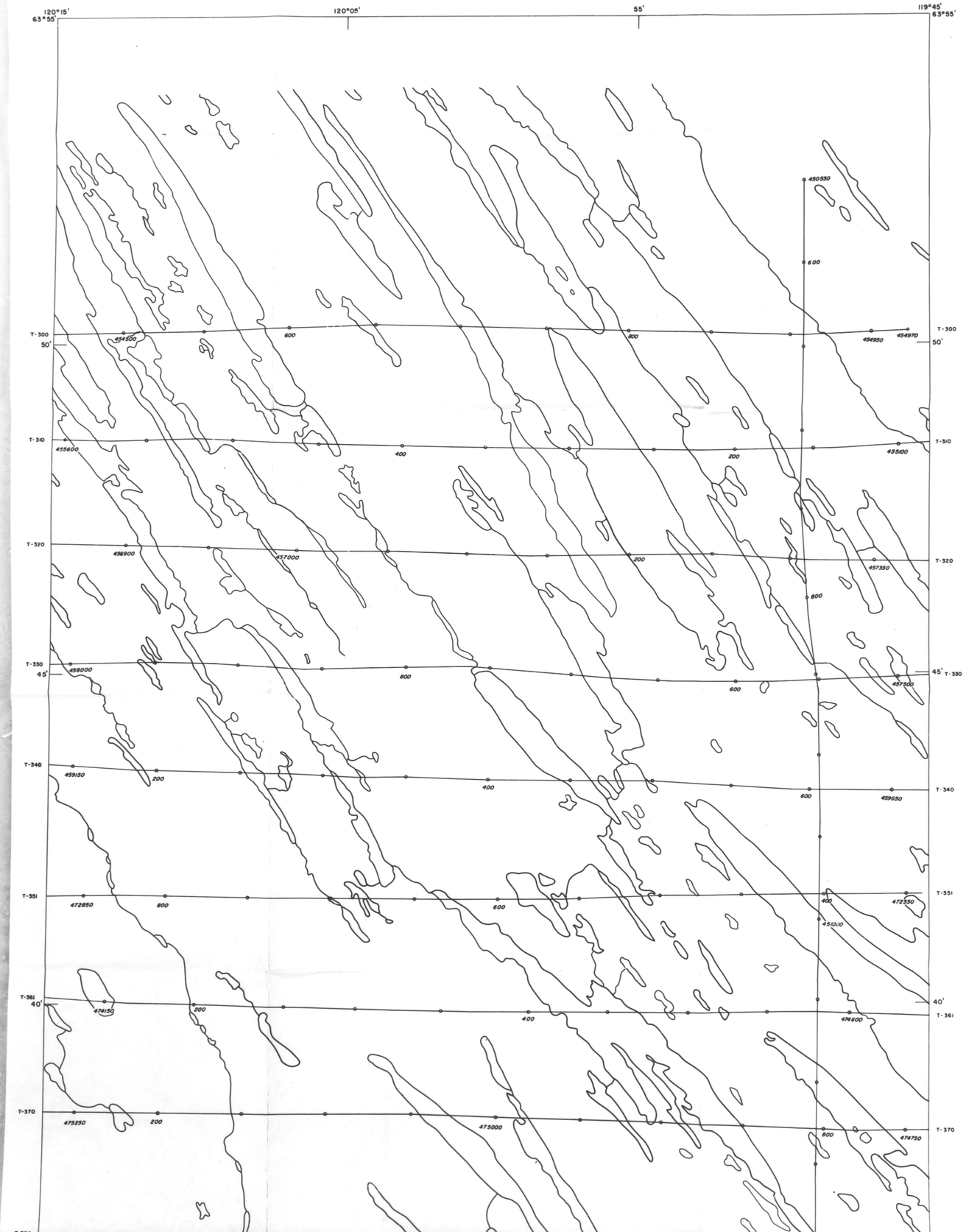
NORMAL VARIATION
CORRECTION APPLIED

HORIZONTAL CONTROL BASED ON
1:250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA

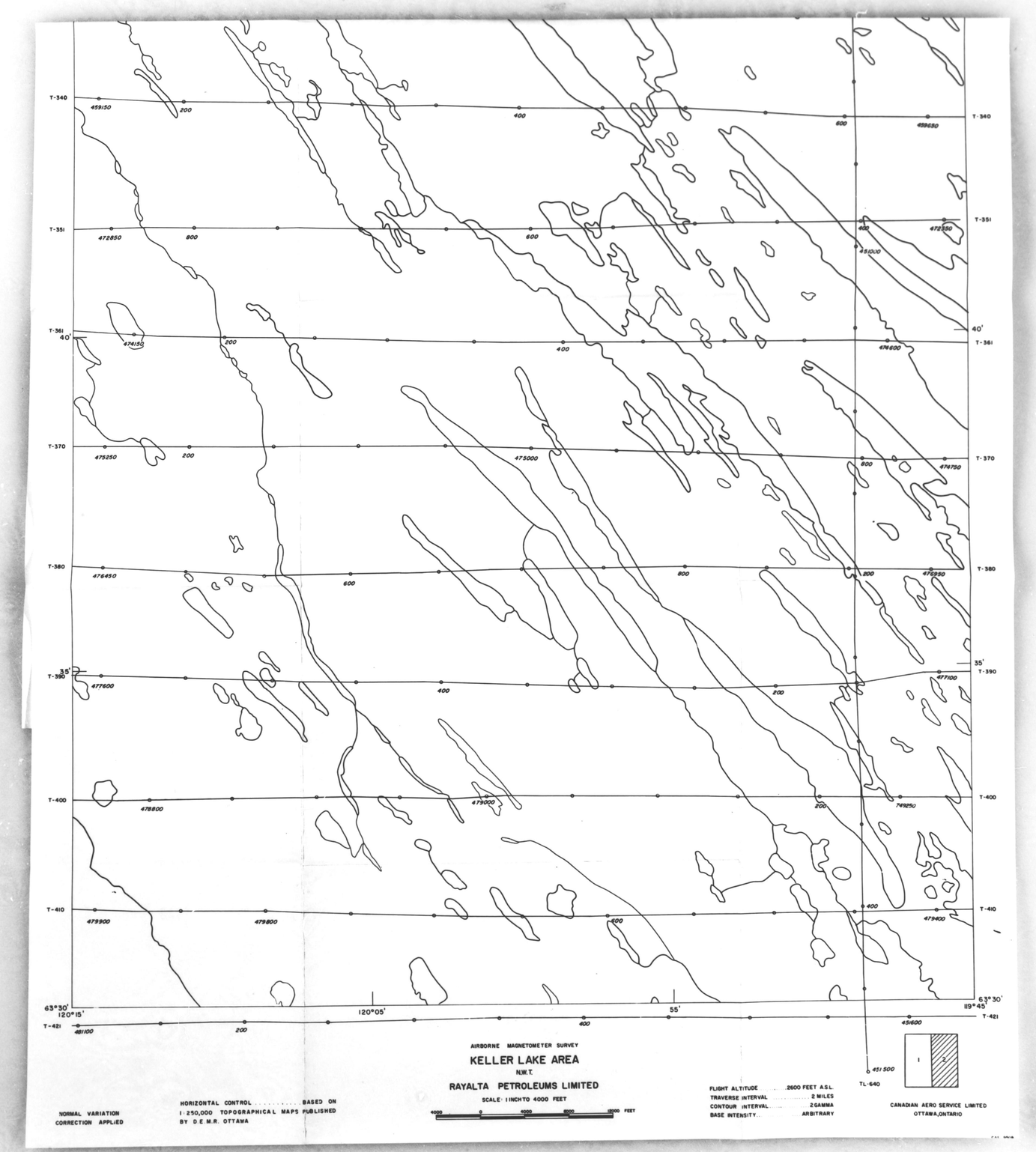
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TRAVERSE INTERVAL	2 MILES
CONTOUR INTERVAL	2 GAMMA
BASE INTENSITY	ARBITRARY

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

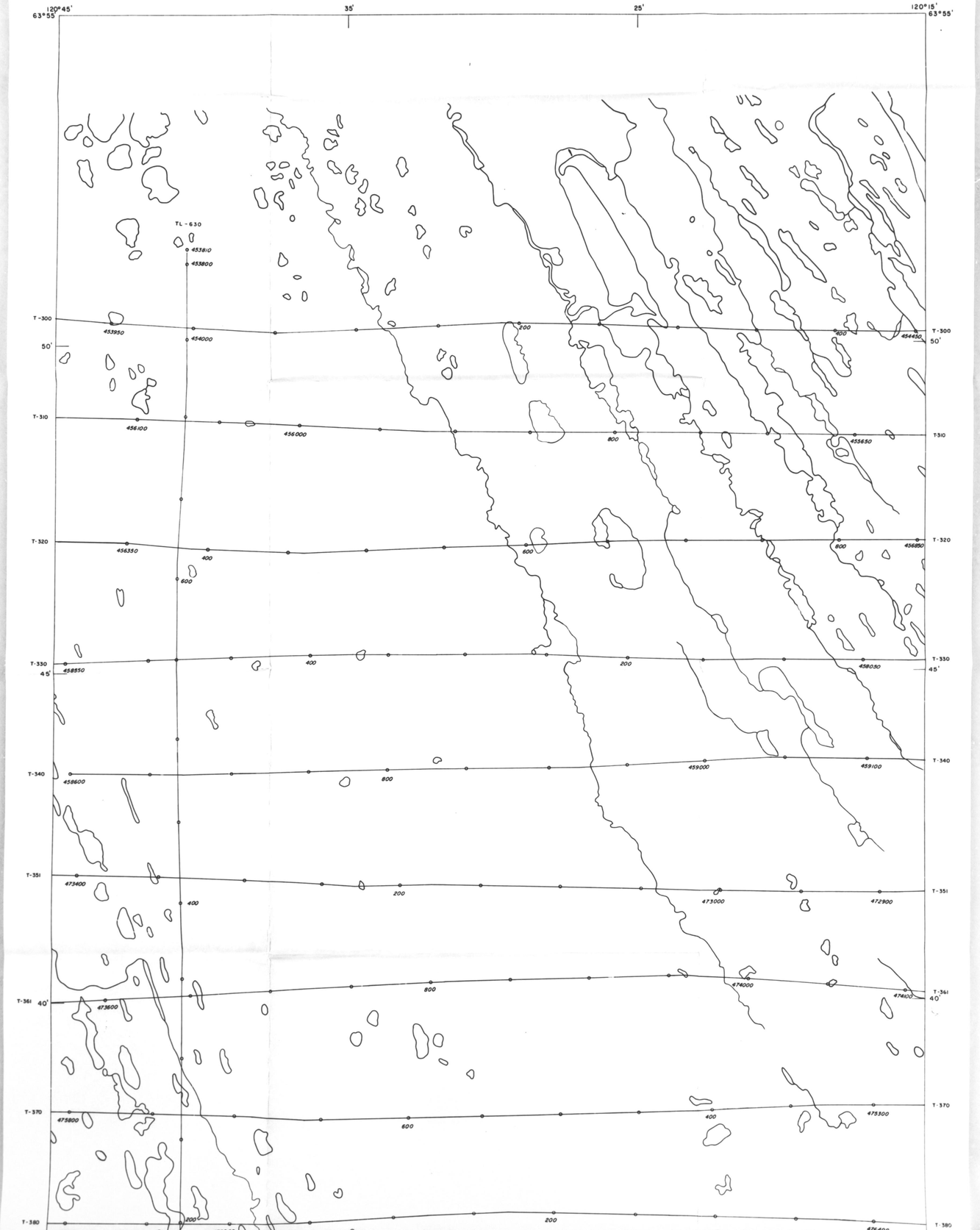
2 OF 2


120°15'
63°55'
120°05'
55'
119°45'
63°55'
T-300
50'
454500
600
800
454950
454970
T-310
455600
400
200
455100
T-320
456900
457000
200
457350
800
T-330
45'
458000
600
600
457500
T-340
459150
200
400
600
459650
T-351
472850
800
600
400
472350
451000
T-361
40'
474150
200
400
476600
T-370
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200
475000
800
476750
450550
600

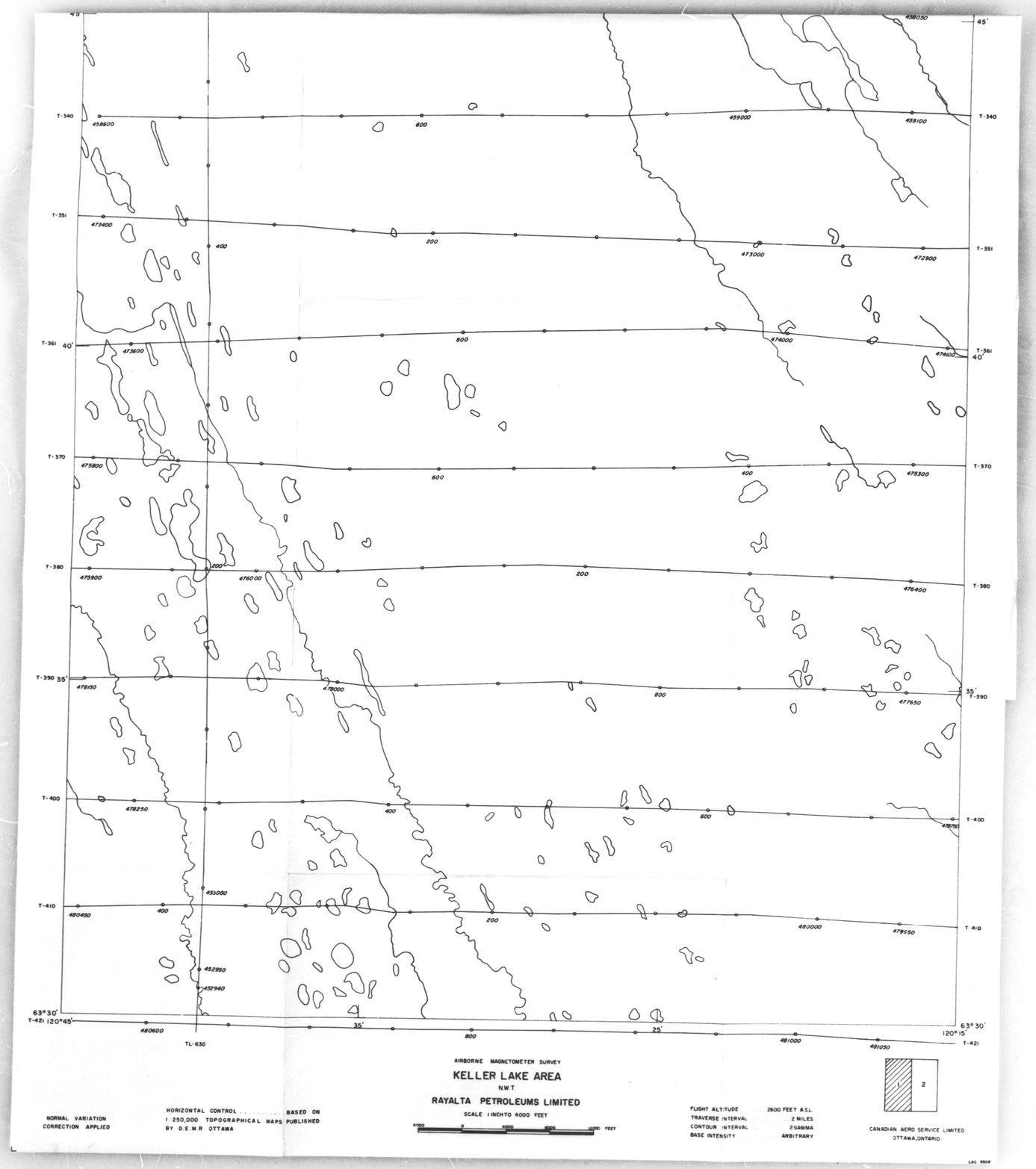
1 OF 2


T-340
459150
200
400
600
459650
T-340
T-351
472850
800
600
400
472350
450430
T-351
T-361
40'
474150
200
400
476800
40'
T-361
T-370
475250
200
475000
800
474750
T-370
T-380
476450
600
800
200
476950
T-380
35'
T-390
477600
400
200
477100
35'
T-390
T-400
478800
479000
200
749250
T-400
T-410
479900
479800
600
400
479400
T-410
63°30'
120°15'
120°05'
55'
119°45'
63°30'
T-421
481100
200
400
454600
T-421
451500
TL-640
1
2
AIRBORNE MAGNETOMETER SURVEY
KELLER LAKE AREA
N.W.T.
RAYALTA PETROLEUMS LIMITED
SCALE: 1 INCH TO 4000 FEET
4000 0 4000 8000 12000 FEET
FLIGHT ALTITUDE ..2600 FEET A.S.L.
TRAVERSE INTERVAL ..2 MILES
CONTOUR INTERVAL ..2 GAMMA
BASE INTENSITY ..ARBITRARY
NORMAL VARIATION
CORRECTION APPLIED
HORIZONTAL CONTROL ..BASED ON
1:250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

2 OF 2


120°45'
63°55'
35'
25'
120°15'
63°55'
TL - 630
453810
453800
T-300
453950
454000
200
400
454450
T-300
50'
50'
T-310
456100
456000
800
455650
T-310
T-320
456350
400
600
600
800
456850
T-320
T-330
45'
456850
400
200
458050
T-330
45'
T-340
458600
800
459000
459100
T-340
T-351
473400
200
473000
472900
T-351
400
800
474000
474100
T-361
40'
473600
T-361
40'
T-370
475800
600
400
475300
T-370
T-380
200
200
T-380

1 OF 2



AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

SCALE 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

NORMAL VARIATION CORRECTION APPLIED

HORIZONTAL CONTROL ..... BASED ON 1:250,000 TOPOGRAPHICAL MAPS PUBLISHED BY D.E.M.R. OTTAWA

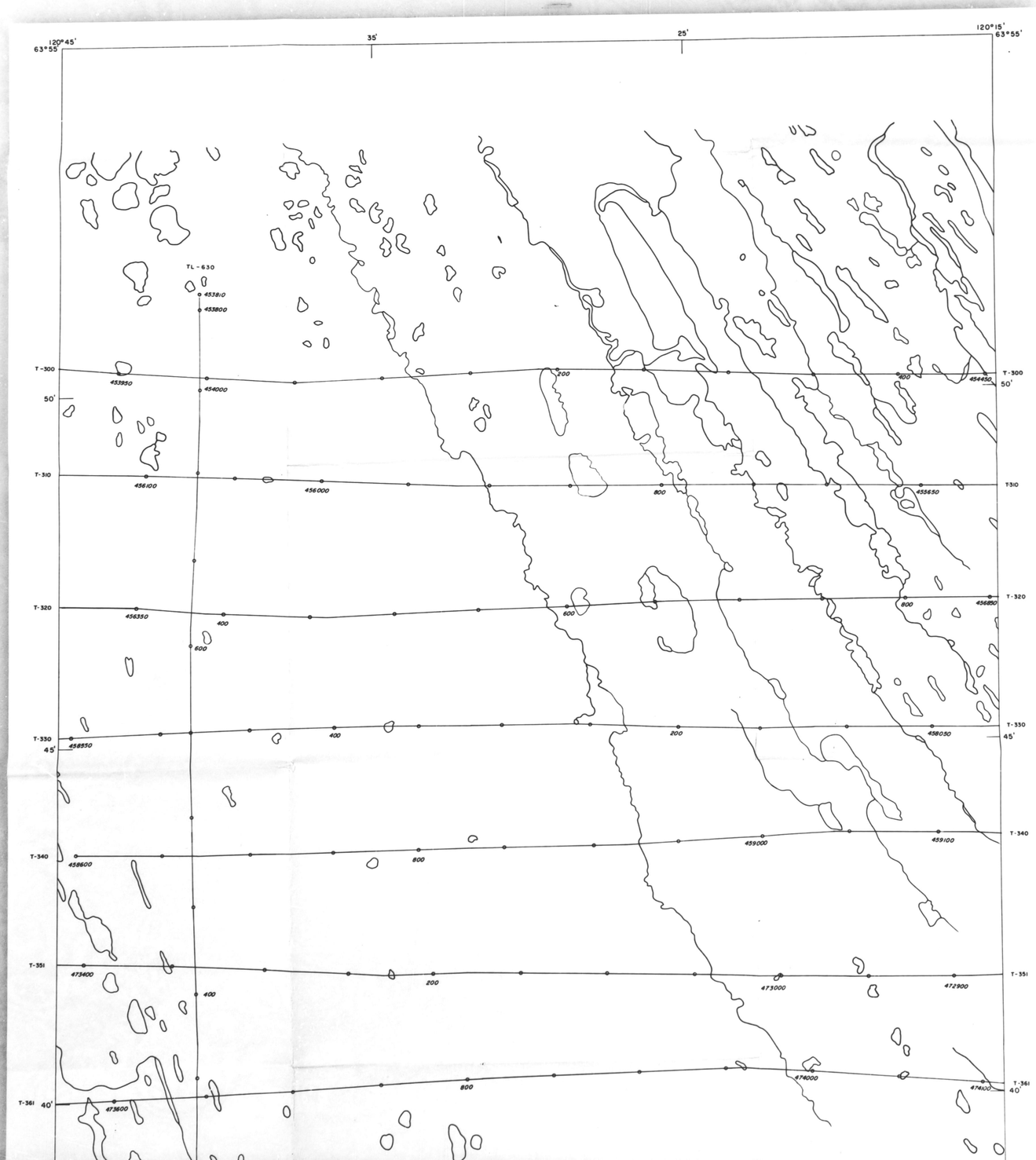
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TRAVERSE INTERVAL	2 MILES
CONTOUR INTERVAL	2 GAMMA
BASE INTENSITY	ARBITRARY

1 2

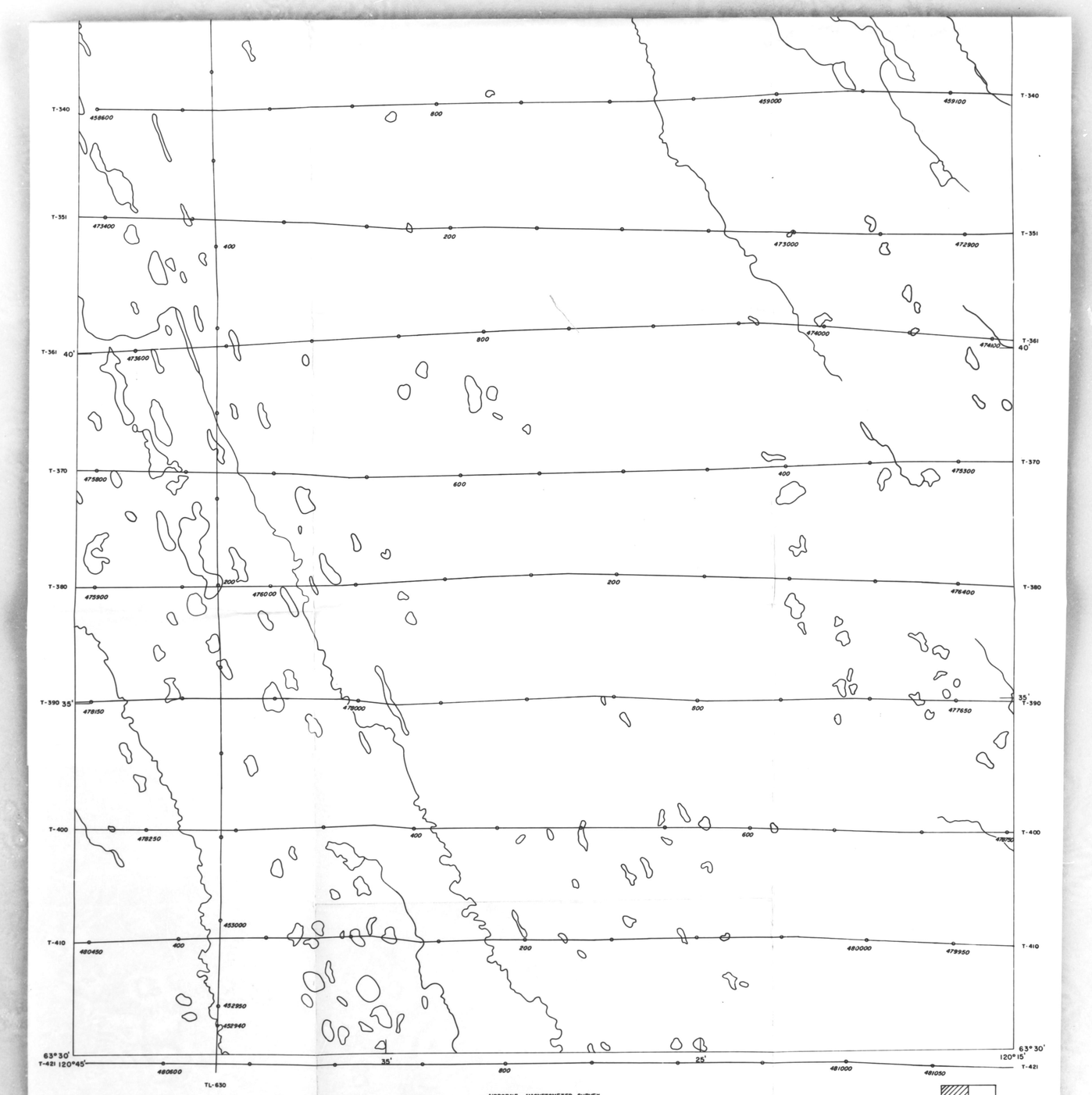
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

CAS 9508

2 OF 2


120°45'
63°55'
35'
25'
120°15'
63°55'
TL-630
453810
453800
T-300
453950
454000
200
400
454450
T-300
50'
50'
T-310
456100
456000
800
455650
T-310
T-320
456350
400
600
600
800
456850
T-320
T-330
458950
400
200
458050
T-330
45'
45'
T-340
458600
800
459000
459100
T-340
T-351
473400
200
473000
472900
T-351
400
800
474000
474100
T-361
T-361
40'
473600
40'

1 OF 2



AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

SCALE: 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

NORMAL VARIATION
CORRECTION APPLIED

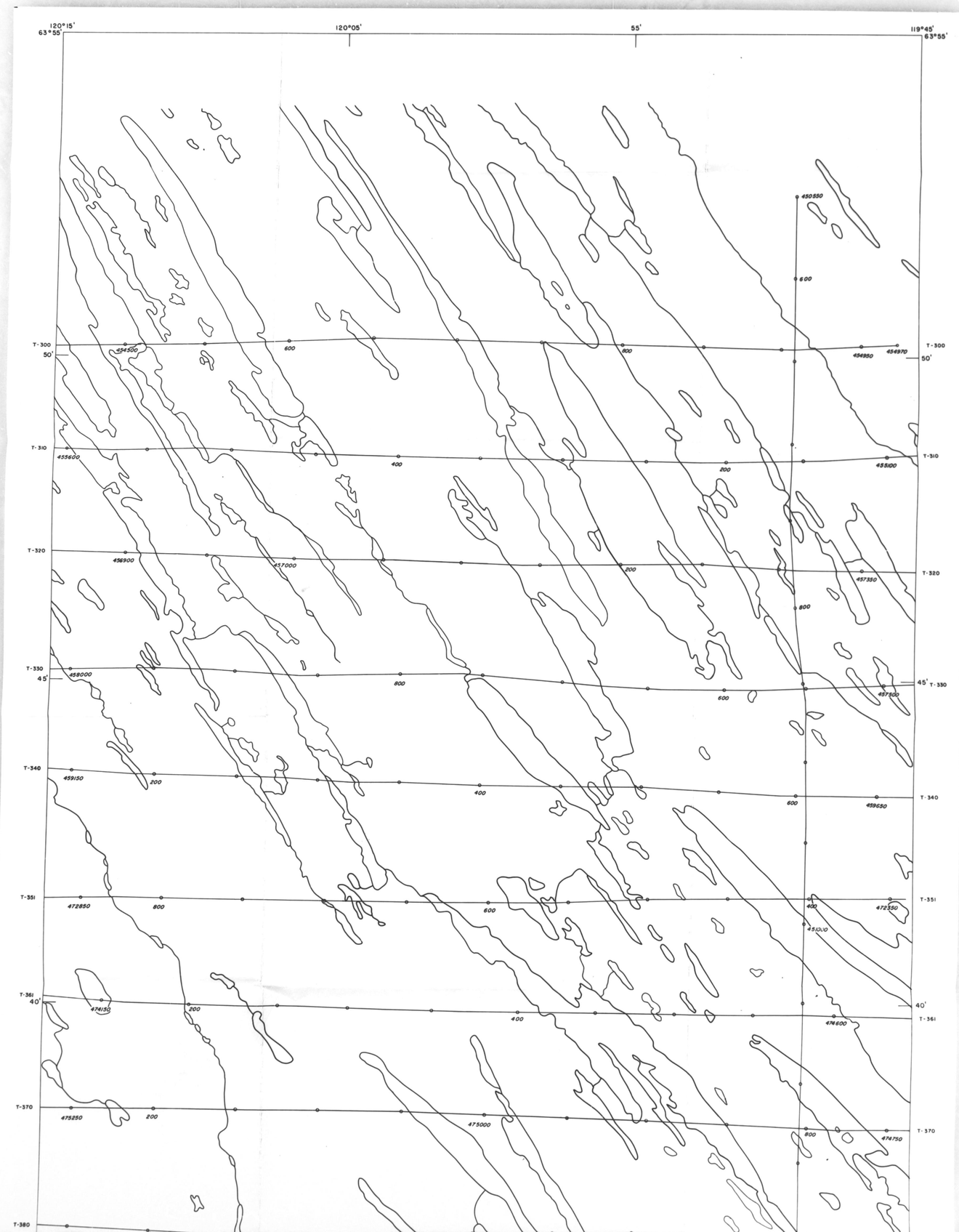
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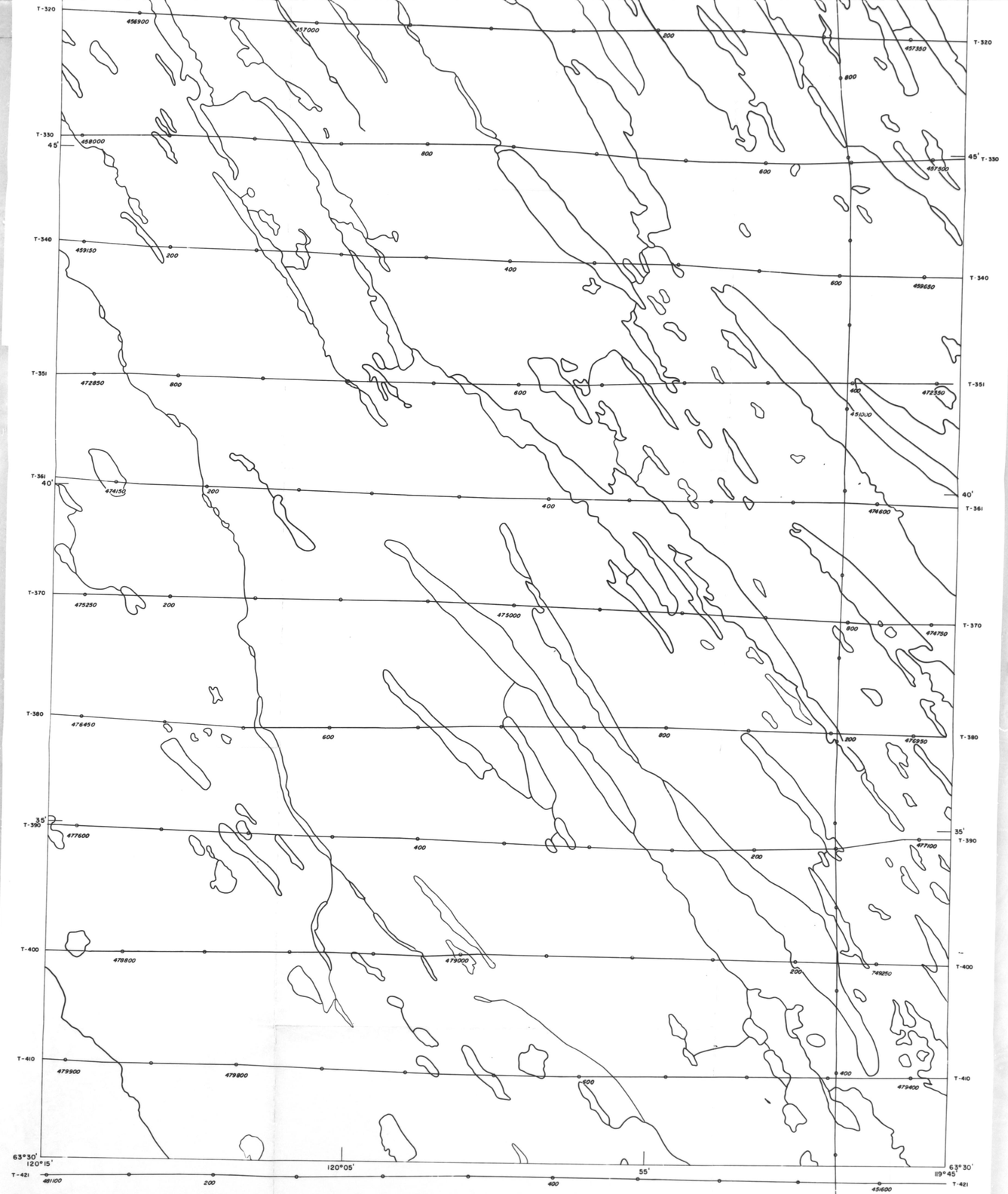
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TRAVERSE INTERVAL ..... 2 MILES
CONTOUR INTERVAL ..... 2 GAMMA
BASE INTENSITY ..... ARBITRARY

1 2

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO.

2 OF 2


120°15'
63°55'
120°05'
55'
119°45'
63°55'
T-300
50'
454500
600
800
454950
454970
T-310
455600
400
200
455100
T-320
456900
457000
200
457350
800
T-330
45'
458000
800
600
457500
T-340
459150
200
400
600
459650
T-351
472850
800
600
400
472550
T-361
40'
474150
200
400
474600
T-370
475250
200
475000
800
474750
T-380
450550
600
451010



AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

SCALE: 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

NORMAL VARIATION CORRECTION APPLIED

HORIZONTAL CONTROL ..... BASED ON 1:250,000 TOPOGRAPHICAL MAPS PUBLISHED BY D.E.M.R. OTTAWA

FLIGHT ALTITUDE	2600 FEET A.S.L.
TRAVERSE INTERVAL	2 MILES
CONTOUR INTERVAL	2 GAMMA
BASE INTENSITY	ARBITRARY

1 2

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

2 of 2

120°15'
63°55'
120°05'
55'
119°45'
63°55'

LEGEND

1000 ..... BASEMENT DEPTH ESTIMATE IN FEET BELOW SEA LEVEL

300 ..... SUPRA-BASEMENT DEPTH

1000 ..... DEPTH CONTOUR

..... PROBABLE FAULT

..... ROCK UNIT OF RELATIVELY BASIC COMPOSITION

..... AREA OF POSSIBLE MINOR BASEMENT RELIEF AND/OR SEDIMENTARY STRUCTURE

T-300
50'
T-310
T-320
T-330
45'
T-340
T-351
T-361
40'
T-370
T-380

900
456900

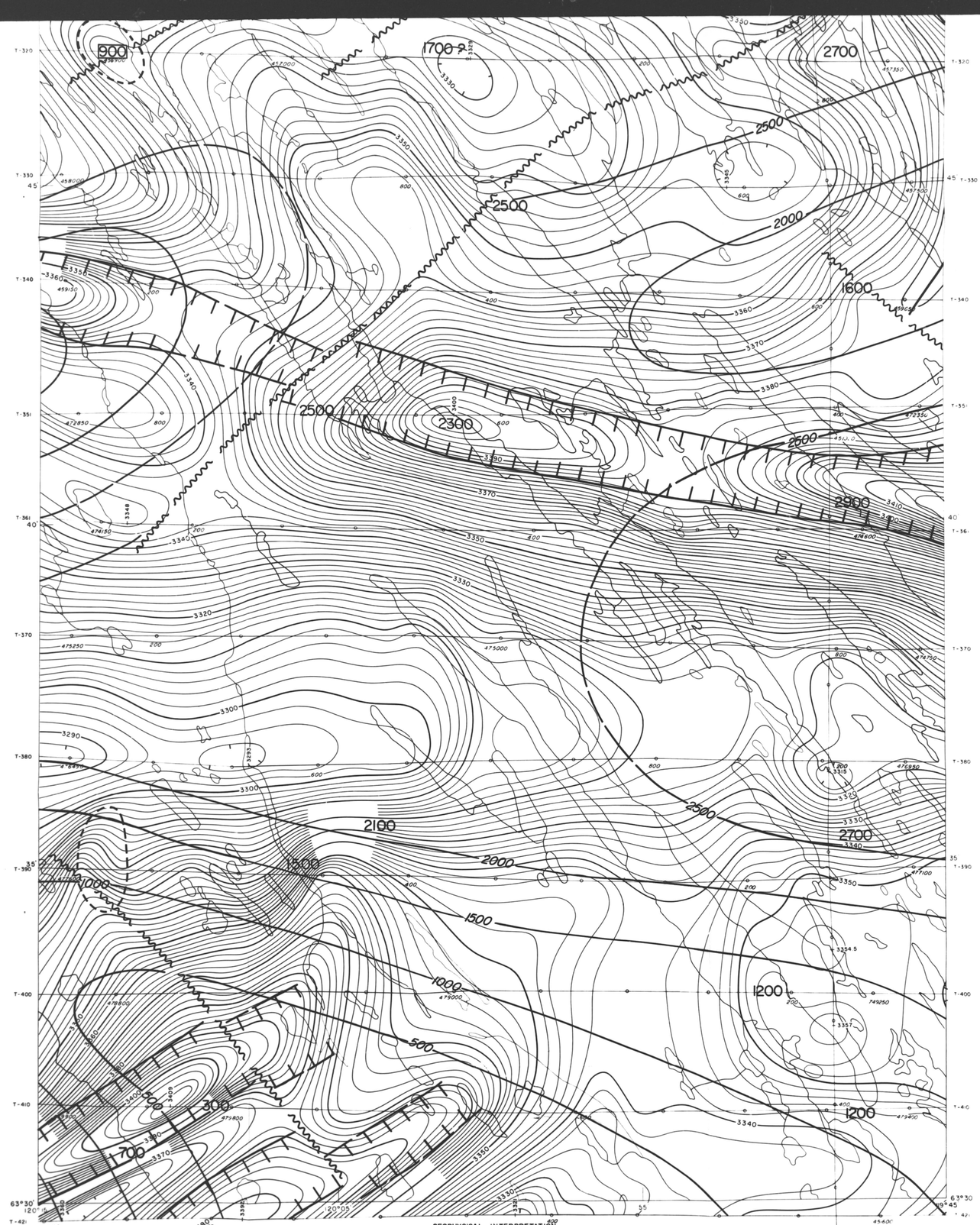
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3320
3300
3290

450550
454500
454950
454970
455600
455100
457000
457350
458000
457500
459150
459650
472850
472350
474150
474600
475250
475000
474750

600
800
400
200

1 of


T-320
T-330
T-340
T-351
T-361
T-370
T-380
T-390
T-400
T-410
T-421
45'
40'
35'
63°30'
120°15'
900
1700
2700
2500
2000
1600
2300
2900
2100
1500
1000
1200
700
500
300
3360
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3720
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3750
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3770
3780
3790

INTERPRETATION REPORT

MAGNETOMETER/GRADIOMETER SURVEY

OF

RAE LAKE AND KELLER LAKE AREAS

NORTHWEST TERRITORIES, CANADA

793-7-4-1

AERO SERVICE
DIVISION OF LITTON INDUSTRIES

INTERPRETATION REPORT

MAGNETOMETER/GRADIOMETER SURVEY

OF

RAE LAKE AND KELLER LAKE AREAS

NORTHWEST TERRITORIES, CANADA

793-7-4-1



TABLE OF CONTENTS

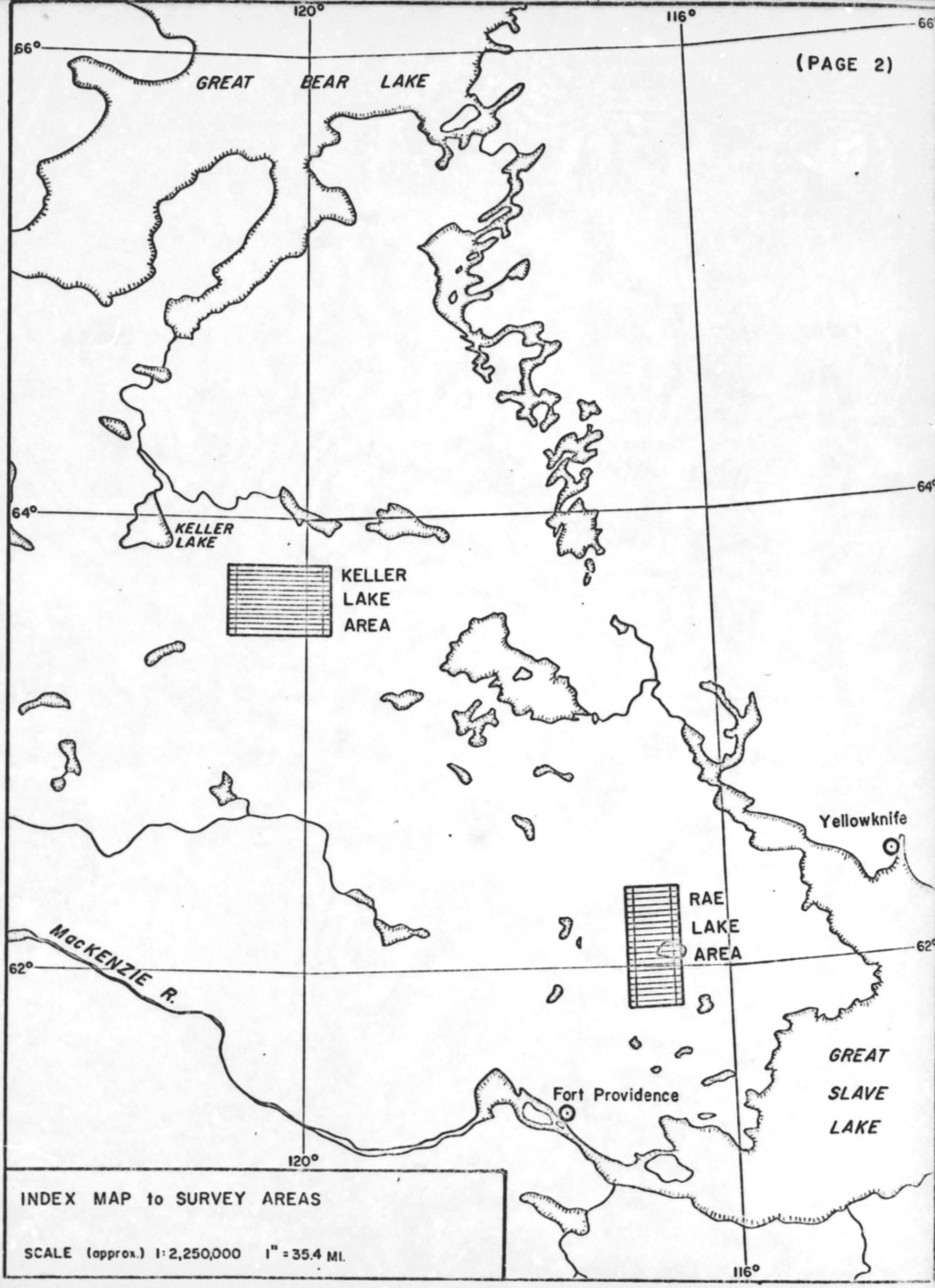
Subject	Page
Introduction	1
Statistics	4
Elements of the Earth's Magnetic Field	6
Interpretation Theory and Procedure	10
General Geology	19
Geophysical Interpretation	21
General	21
Keller Lake Area	22
Rae Lake Area	26
Conclusions	30
Bibliography	31

INTRODUCTION

On September 16 and 17, 1968, an airborne magnetometer/gradiometer survey was performed over two areas in northwestern Canada for Rayalta Petroleum Limited by Canadian Aero Service Limited. The two areas, designated as Rae Lake and Keller Lake, are located in the Northwest Territories in the region between Great Bear Lake and Great Slave Lake. The index map overleaf shows the approximate location and areal extent of the survey work.

The survey was performed using two alkali vapor magnetometers trailed from a DC-3 aircraft and separated vertically by 220 feet at the aircraft air speed of 155 miles per hour. The total magnetic field intensity was recorded from the measurement of the lower sensor, while the vertical magnetic gradient was recorded from the difference in total magnetic field intensity between the upper and lower sensors.

The survey aircraft was flown at a constant barometric altitude of 2000 feet above sea level over the Rae Lake Area, and 2600 feet above sea level over the Keller Lake Area. The altitude of the lower sensor was approximately 1720 feet and 2320 feet above sea level, respectively. The flight direction


120°
116°
66°
GREAT BEAR LAKE
64°
KELLER LAKE
KELLER LAKE AREA
Yellowknife
RAE LAKE AREA
62°
MacKENZIE R.
Fort Providence
GREAT SLAVE LAKE
INDEX MAP to SURVEY AREAS
SCALE (approx.) 1:2,250,000 1" = 35.4 MI.

of the traverses was east-west in the case of both areas. The distance between adjacent parallel traverses was two miles.

Navigation for the survey was obtained with a Doppler navigation system and monitored by a 35 mm. strip-film camera. These two positioning devices were used in recovering the aircraft position in the compilation stages. The digital fiducial interval (distance between data points) was 152 feet, and this was controlled by the Doppler along-path computer. The data was obtained both in analog and digital form in the aircraft, and the chart speeds for the analog recording were set to record the data at 1:30,000 scale.

During the course of the survey, a Gulf fluxgate magnetometer was operated on the ground to monitor diurnal conditions. This instrument was set at a full-scale sensitivity of 250 gamma. Data were recorded at three inches per minute on 5" chart paper at the base station of Yellowknife.

Only the total magnetic field data were compiled in map form. The compilation is presented at a scale of 1:48,000 (one inch equals four thousand feet) on one map sheet for the Rae Lake area and two sheets for the Keller Lake area. The results of the geophysical interpretation discussed herein are shown superimposed on the isomagnetic contour maps. Details of the interpretation procedures are described in a following section.

STATISTICS

CLIENT.....Rayalta Petroleums Limited

CONTRACTOR.....Canadian Aero Service Limited

AREA DESIGNATION.....Rae Lake and Keller Lake

PROJECT REFERENCE NUMBER.....9519

COMMENCEMENT OF FLYING.....September 16, 1968

COMPLETION OF FLYING.....September 17, 1968

OPERATIONAL BASE.....Yellowknife, Northwest Terr.

SENSORS.....Two Alkali Vapor Magnetometers

MAGNETOMETER INSTALLATION.....Two trailing sensors with a separation of 220 feet, at 155 m.p.h. air speed.

Analog Recorder.....Mosely 10" Rectilinear Recorder

Analog Chart Scale.....Total Field: 200γ/10 Major Chart Divs.
Gradient: 5γ/10 Major Chart Divs.

Analog Chart Speed.....Doppler driven for a horizontal scale of 2.4" per nautical mile

Digital Recorder.....Magnetic Tape

Digital Recording Increment..Total Field: 1/50 gamma
Gradient: 1/10,000 gamma per 220 Ft.

ALTIMETERS.....Minneapolis Honeywell Radar Altimeter
Rosemont Barometric Altimeter

Analog Recording Scale.....0 - 5,000' Full Scale (Radar only)

Analog Chart Speed.....Doppler driven for a horizontal scale of 2.4" per nautical mile

Digital Recorder.....Magnetic Tape

STATISTICS (Cont.)

ALTIMETERS (Cont.)

Digital Recording Increment..5.0 feet (Barometric only)

FLIGHT ALTITUDES.....	Rae Lake	Keller Lake
Aircraft.....	2000'	2600'
Lower Sensor.....	1720'	2320'

FIDUCIAL INTERVAL (Doppler computed).....Index Fiducials - 1520'
Digital Fiducials - 152'

GROUND MONITOR.....Gulf Fluxgate Magnetometer

Sensitivity.....250 gamma full scale

Chart Speed.....3 inches per minute

LINEAR MILEAGE,.....			
	Rae Lake	430	miles
	Keller Lake	464	miles
	Total	894	miles

SQUARE MILEAGE.....			
	Rae Lake	570	square miles
	Keller Lake	730	square miles

FLIGHT LINE SPACING & DIRECTION:

Traverses.....E-W at 2 mile interval

Tie Lines.....N-S at a variable interval

NAVIGATIONAL AIDS.....Bendix Doppler

DIGITAL SYSTEM.....An incremental digital recording of magnetometer output, gradiometer, fiducial numbers, time, Doppler cross track and altitude deviations

MAP PRESENTATION SCALE.....1:48,000

TOTAL FIELD INTENSITY.....59,500 gamma to 60,000 gamma

MAGNETIC INCLINATION....81°N MAGNETIC DECLINATION...34°E & 37°E

THE EARTH'S MAGNETIC FIELD

A magnetic field, such as that of the earth, is vectorial in nature, since at any point it is characterized by magnitude and direction. On the earth's surface this vector field is conventionally described by its intensity and by two angular elements defining its direction.

The unit of intensity by which the earth's field is measured is the gamma (γ), which is equal to 1×10^{-5} oersted. The oersted, the c.g.s. standard of magnetic intensity, is by definition the intensity extant at a point one centimeter from a unit magnetic pole. The direction of the earth's field is defined by its declination, the horizontal angle between the intensity vector and geographic north, and by its inclination, the vertical angle between the vector and the tangent to the earth's surface.

The field on the earth's surface resembles in its gross aspects the field distribution that would result were it caused by a relatively short bar magnet located in the center of the earth and inclined about twenty degrees to the geographic polar axis. Therefore, a magnetic equator exists in the tropics, inclined about twenty degrees to the geographic equator, which passes through Peru, Bolivia and Brazil in

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South America; Sierra Leone, Nigeria, Sudan and Ethiopia in Africa; and Ceylon, Thailand and the Philippines in the Orient. Along this line, the magnetic inclination is zero; that is, the intensity vector is horizontal with respect to the earth's surface. The magnetic poles, the points on the surface at which the intensity vector is perpendicular to the earth's surface, are located at the north end of Prince of Wales Island, Canada (the north magnetic pole) and on the coast of the Australian-claimed sector of Antarctica (the south magnetic pole).

Using the bar magnet approximation, the total intensity of the earth's magnetic field is defined at any point as:

$$T=M/r^3 \ (1 + 3 \sin^2 \phi)^{\frac{1}{2}}$$

Where:

T = intensity of the earth's total field

M = earth's magnetic moment

ϕ = magnetic latitude

The magnetic latitude, ϕ, is related to the magnetic inclination, i, as follows:

$$\phi = \tan^{-1} (\tfrac{1}{2} \tan i)$$

The bar magnet expression indicates that the intensity at the magnetic poles is double that at the magnetic

equator. This is in agreement with field observation; the general intensity at the poles is about seventy thousand gamma, and along the magnetic equator it is about thirty-five thousand gamma. The transition from equator to pole is gradual and systematic in both direction and intensity.

The earth's surface field would presumably follow the bar magnet distribution perfectly if the planet was perfectly homogeneous in composition and magnetic properties, or if it was composed of concentric shells of homogeneous composition and properties. However, the near-surface magnetic disturbances, mainly the rocks of the upper mantle, cause local distortions in the idealized field of the earth. These magnetic anomalies, manifesting geologic structures and rock units, are caused by variations in the concentration and distribution of the magnetic minerals, primarily magnetite. The relatively local magnetic disturbances are the diagnostic features in airborne magnetometer surveys. Their shape and intensity are determined by many factors. Of these factors, the regional inclination and intensity are of critical importance. The remaining factors are properties of the causative body itself; composition, shapes, size, orientation, etc.

The proportion and direction of remanence in the causative body, as compared to induced magnetization, is

another important factor in the determination of the characteristics of the magnetic anomaly. This, however, cannot be assessed without laboratory study of many oriented samples of the body causing an anomaly; therefore, induced conditions are normally assumed in airborne magnetometer exploration.

INTERPRETATION THEORY AND PROCEDURE

The advent of the high sensitivity nuclear precession types of airborne magnetometers and complementary digital data recording techniques has permitted the direct application of electronic computers to the problems of interpretation. Rigorous quantitative calculations previously considered too time consuming have now become feasible, significantly enhancing the interpretive possibilities of magnetic data.

Of the many paths of interpretation opened by the digital data-digital computer combinations, Aero employs principally the process of direct computation of the apparent causes of every interpretable non-linear event on the magnetic profile, a process we refer to generally as "deconvolution".

An approximation assumed in all airborne geophysical surveying is the equivalence of the variations of the scalar of the total field to the projection of the anomalous vector upon the total field vector. This approximation is adequate for all normal anomalies which may be encountered in petroleum exploration. A consequence of this assumption is that any anomaly may be synthesized by the straightforward numerical addition of the supposed component anomalies.

Our methods are an extension of the interpretation methods outlined by S. Werner in his paper "Interpretation of Magnetic Anomalies at Sheet-like Bodies", (Stockholm, 1953). Werner points out that in the simple case where observations are made in a level plane over level-bounded bodies whose strike is infinite and at right angle to the profile, an interpretation equation in the form:

$$a_o + a_1x + b_oF + b_1xF = x^2F$$

may be written. In this equation, a_o, a_1, b_o and b_1 are the parameters of the interpretation equation, X represents distance along profile, and F represents the total field at x. Each of these parameters involves one or more of the four physical unknowns of the situation: the magnetization parallel with the plane of the sheet; the magnetization perpendicular to the plane of the sheet; the distance from the observation point to that point which lies immediately above the edge of the sheet; and the depth of the upper edge of the sheet from the plane of observation.

There being four unknowns, simultaneous solution of four equations involving x and the corresponding F will determine the parametric function, and from them the physical attributes referred to above. In the simple case, the geometric solution is complete; and for purposes of exposition only a

simple case will be considered here, although the addition of other parameters and other equations at other observation points will permit extension of the solution to more general cases.

It should be pointed out that the above theory is valid for all semi-infinite, homogeneous, sheet-like bodies, whatever their strike or dip, as long as the width of the sheet is not greater than 2.5 times the depth to the top edge of the sheet. If such is not the case, however, the theory can be extended by the recognition that such a body--a "thick" sheet"--can be considered as being bounded by two interfaces.* It is interesting that the magnetic anomaly for a thin sheet is precisely the derivative of the magnetic anomaly for a similarly positioned interface. Thus, by performing a "deconvolution" on both the total field and the horizontal (or vertical) derivative of the total field, we are able to identify and calculate the pertinent characteristics of thick sheets and individual interfaces, as well as thin sheets.

Our observation of total field having been made at equal linear intervals along the profile line, the computer

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*All "thin sheets" are bounded by two interfaces, but the interfaces are too close together for their individual anomalies to be distinguishable from one another--the combination of the two results in a single thin sheet anomaly.

now examines four successive equally spaced points and solves the set of linear equations for the physical parameters of interest at the position of the indicated anomalous body. The entire sequence of points is now advanced by one unit and the examination is repeated. If a succession of such examinations consistently indicates a source for the anomaly being observed, and if the indications (checked one to another) are themselves consistent, then the computer will indicate the apparent depth and along-profile coordinate positions of events as seen from each successive set of data points. These sets of coordinate positions of events are then recorded for subsequent plotting to scale by the CalComp plotter.

Since the sensitivity of the four point array to the detection of an anomalous source will be strongly related to the observational distance subtended by the array, the computation described above is repeated, first with observation points separated at an interval of three observation units, (the observed points, in our general practice, are 304 feet apart) and then with successive points separated at an interval of nine observation units, and then again at an observation interval of twelve units. In this manner, suitable "sensitivity" to events over a considerable depth beneath the observation plane becomes possible. These unit separations

are not invarient, and can be substituted for other unit separations in combination with various filter parameters to more precisely define specific depth bands.

Due to the fact that no empirical data can exactly match the signature of a theoretical model, the depth and position coordinates which derive from the computational sequence are not quite identical from one observational set to the next; and as a consequence, certain distinctive groupings of indicated points will occur for many of the anomalies. Since the richness of the data production offered by the method is so great that hundreds of such point groups appear, and since the groups will have continuity line to line, both of these aspects of the technique are used as weighting factors in evaluating depth points.

Concurrently with the solution of the parametric equations of the total field, the solution of the parameters for the first horizontal derivative of the total field and the vertical gradient (if it has been measured) are carried out, using identical parametric formulas. By this means additional depth solutions are obtained, from assumptions based on another source model. In particular, since the parametric formula for an interface, in the context of this discussion, is identical with the derivative either in Z or in X of the formula for a

thin sheet, the solutions have been extended--at the cost of some ambiguity, which must be solved from geologic considerations--to the cases of both dikes and interfaces. The power of the equations employed for direct interpretation of magnetic anomalies, permits solution of anomalies even when only parts of them are undisturbed by adjacent anomalies. Solutions are found from any four points in sequence, and these points need not be predetermined or be critical points or otherwise special points along the profile.

In the above discussion, only the simplest case is discussed. In our actual interpretations, we measure six parameters, involving six unknowns of the geological sources; and we interrelate groups of adjacent lines so that the error inherent in the depth calculations (which arise from the fact that in a real world, geologic strikes are neither infinite, nor do they always lie at right angles to the observation profiles) can be evaluated and corrected. As we refine our programs, we will add even more observation points and solve more of the pertinent equations affecting an interpretation.

Once this analysis has been completed there still remains the task of collating this data into a coherent set of geological circumstances. This phase of the interpretation can be conveniently separated into two general categories:

a) the qualitative recognition of structural and petrological units, and b) the quantitative assessment of anomalies or groups of anomalies with regard to depth, dimension, body parameters and susceptibility. Most of the latter has been accomplished when the computer analysis is complete.

In the delineation of rock units, the criteria are the frequency, extent, shape and orientation of the local anomalies; and the general intensity levels of the magnetically anomalous zones. These rock units, whether they be sedimentary units or crystalline basement units will not, in all cases, correspond to contacts mapped in the field on the basis of observed stratigraphic criteria. The reason for this is that stratigraphically different formations having similar magnetic mineral concentration and distribution will be expressed by similar magnetic patterns, while conversely, lithologic contrast within the same geologically mapped unit will give rise to contrasting magnetic patterns.

With few exceptions, the magnetic character of sedimentary rocks is very weak as compared to that of igneous and metamorphic rocks. Large local distortions in the natural magnetic field are, therefore, considered to arise primarily from the igneous and metamorphic basement. In general, the stronger the local magnetic relief and intensity, the greater

the proportion of magnetic minerals (chiefly magnetite) that is in the rock unit influencing the magnetic pattern. By further inference, the more likely it is to have a more basic composition. The smaller distortions of the field, in contrast, which are frequently present in equal or greater abundance than the larger features, are more likely to be caused by local basement relief or by magnetic effects in the sedimentary section.

Faults may be manifested magnetically by dislocations or disruptions in magnetic pattern or by persistent changes in pattern over long distances. Plugs, dikes and other igneous phenomena are inferred from the shape and intensities of the associated magnetic features. Recognition of such features is, to some extent, subjective in nature.

The dimensions, depth and susceptibility of the sources of the intense anomalies have been calculated, for those features that approximate two-dimensional conditions, by curve comparison against idealized tabular body standards. The susceptibility contrast is critically dependent on the assumed or interpreted width of the source body; if the true width is less than the assumed width, the susceptibility contrast will be greater than calculated, and vice versa. In

relating susceptibility contrast to percentage of magnetite by volume in excess of magnetite in the country rock, a figure of 0.3 c.g.s. units for the susceptibility of pure magnetite is commonly used.

All methods of quantitative study require assumptions of homogeneity and idealized shape. Inasmuch as rock bodies cannot be expected to satisfy these assumptions except under the most unusual of circumstances, quantitative conclusions should be regarded as estimates of magnitude rather than precise determinations.

GENERAL GEOLOGY

Both areas are located in the northern portion of the western Canada sedimentary basin near its eastern margin. In this region, the crystalline basement is in all essential respects a westward continuation of the Precambrian rocks exposed on the Canadian Shield a few miles to the east. The westward slope of the Precambrian complex beneath the overlying Paleozoic and Mesozoic sediments is very gentle, and only a relatively thin sedimentary layer would be expected to be present. The youngest formations exposed in the Rae Lake area are Lower to Middle Devonian in age, while in the Keller Lake area, formations of Cretaceous age comprise the principal outcrops. The Cretaceous section here is probably quite thin, however, as evidenced by the widespread occurrence of Lower Paleozoic rocks to the south and east less than ten miles away.

In general, the geological framework of the area does not appear favorable for the accumulation of petroleum. Experience gained in the exploration and development of petroleum reserves further south in the western Canada basin (Peace River region, etc.) has shown that a great thickness of section is not a primary requirement for oil accumulation in this region, although the

section there is considerably thicker than in the areas of the present survey.

GEOPHYSICAL INTERPRETATION

General

The depth and general configuration of the basement surface in the two areas, as shown on the accompanying interpretation maps, is based primarily on the computer techniques of analysis outlined earlier. In a number of cases, the analog records were analyzed by graphical methods as an approximate comparison with the computer-derived depths. The results of this comparative study show that there is a general agreement between the two methods in the case of the relatively shallow depths up to about one thousand feet below sea level. In the case of the deeper computer-derived depths, particularly those in excess of two thousand feet below sea level, the graphical solutions consistently indicate more shallow values. Since the derivation of these deeper depths involves several sets of mathematical filtering and operator spacings, as described earlier, it is difficult to precisely define the degree of validity of the computed values in many cases. It will be noticed, however, that many of the exceptionally deep depth estimates are followed by a question mark on the map, indicating their questionable nature. Moreover, most of these have not been completely contoured even though they

have influenced the general depth contour pattern.

Keller Lake Area

The magnetic pattern displayed in this area is moderately complex. The principal anomalies are rather broad and quite elongate in shape with a predominant east-west trend. This direction of trend presents a problem in obtaining estimates of depth, inasmuch as the traverse direction parallels most of the diagnostic magnetic gradients. Depth information in the central position of the area is particularly scanty for this reason, and those depths which were obtained may in many cases be excessively deep.

An abrupt departure from the general anomalous orientation is observed along the western margin of the area and again in the extreme northeastern corner. In these localities, the magnetic trends are essentially north-south. These changes in trend are accompanied by an increase in local magnetic relief, particularly in the case of the zone along the western margin of the area where the magnetic intensity attains a maximum of one hundred seventy gamma. The partially-mapped anomaly in the northeastern corner has a maximum observable amplitude of one hundred twenty gamma.

In contrast to these localities of maximum relief, the local magnetic response throughout most of the area has a general range between fifty and one hundred gamma.

The elongate east-west magnetic trends comprising the major portion of the area are interpreted as the expressions of elongate, tabular shaped units of rock which are relatively more basic in composition than their surroundings. Two principal zones are observed, one trending east-west to northwest across the northern half of the area and the other trending northwest-southeast across the western half. The zone in the north is relatively continuous, although minor offsets in the trend are present which are interpreted as evidence of faulting in a northerly to northeasterly direction. The zone in the west is not so well defined and, moreover, is severely broken up by at least two large offsets in the anomalous trend. These offsets are interpreted as faults, although with some reservations since the apparent horizontal displacement of each is indicated to be as much as three miles.

In the south-center of the area near the southern boundary, a broad, twin-peaked positive anomaly is present which has a northeast-southwest orientation. This feature

is interpreted as two closely spaced, tabular bodies of relatively basic rock which may represent a repetition of section caused by a relatively tight, local fold in the basement formations. The abrubt termination of the anomaly to the northeast lends support to this interpretatinn, although the nose of the structure is not expressed in the magnetic contours. A southeasterly-trending fault interpreted as passing through this locality adds to its structural complexity. Although this zone extends beyond the southern boundary of the area, it appears to have some relation to the extensive, southeastward-trending zone discussed above. Possibly the two features describe opposite limbs of a broad fold or flexure of the basement units.

The two zones of predominantly north-south magnetic trends in the southwest and northeast portions of the area are interpreted as the expression of basement rock units of relatively basic composition. Since the zones are only partially mapped by the survey coverage, it is not possible to determine the extent and configuration of these causative units. An examination of the mapped portions, however, suggests that the unit in the northeast may be relatively local, and possibly be structurally related to the elongate,

east-west trend located immediately to the south. The zone in the west, in contrast, is apparently much larger in areal extent, and may represent a major lithologic and structural discontinuity in the basement complex.

Estimates of the depth to basement in the area range from sea level to 3000 feet below sea level. The basement surface revealed by the depths is erosional in nature, as evidenced by the poor degree of correlation between its present configuration and the ancient structural elements defined by the magnetic pattern.

Two broad areas of positive basement relief are present in the central portion of the area, one in the north and the other in the south. Both have a general east-west trend. They are separated by a broad, elongate, east-west trough which passes through the center of the area and terminates against an interpreted fault zone bordering the north-south magnetic discontinuity described above. A maximum depth of 3100 feet below sea level is indicated near the western terminus of this trough. The western side of the area exhibits a gradual rise of the basement surface to the west. Minimum depths of 300 feet below sea level are estimated along the western boundary.

A second zone of negative basement relief, more

localized than the central trough, is suggested in the northwestern portion of the area by a series of depth estimates in excess of 2000 feet below sea level. A possible maximum of 3000 feet was obtained on the eastern side of this depression, but its validity is questioned because of its position on the anomalous gradient as well as the small angle of incidence between the gradient and the traverse direction.

Three local areas of possible minor basement relief and/or sedimentary structure are outlined in the north, west and south-center of the survey block. Two of these are associated with relatively shallow depths, suggesting supra-basement structural sources.

Rae Lake Area

The magnetic contour pattern displayed in this area is considerably more complex than that of the Keller Lake region. The individual anomalies are much more localized, smaller in areal extent, and moreover, are substantially higher in intensity. The predominant magnetic trends are north-south to northwest-southeast, although local exceptions are prevalent throughout the region. These local divergent trends, which are generally oriented northeast-southwest to east-west, are for the most part interpreted as the manifestation of basement faults.

A large proportion of the magnetic response observed in the area is comprised of rather extensive zones of relatively high amplitude anomalies. The local magnetic relief in these zones ranges from about 150 to 300 gamma, although significantly higher amplitudes are attained in the north-center and southeastern portions of the area, where anomalies with relief in excess of 500 gamma are observed. These zones are interpreted as the expression of changes in composition of the basement rocks from relatively acidic to relatively more basic varieties. The complex configurations of the rock units thus defined suggest that the basement is quite complicated structurally. Few of these Precambrian structures, however, appear to be expressed in the present basement surface which is principally erosional in nature.

The basement surface, as determined from depth estimates to the sources of the magnetic anomalies displayed, is somewhat shallower here than in the Keller Lake area. The basement is indicated to be very near the present topographic surface in the vicinity of Birch Lake and again in the northwestern corner of the area. The Birch Lake high is a rather broad, gently sloping feature forming a portion

of an extensive positive region which underlies most of the central and eastern parts of the area. The zone of positive relief in the northwest is apparently more localized. It comprises an elongate, east-west trending basement ridge which drops off rapidly to the north and south to depths in excess of 1500 feet below sea level. Many of these depths, particularly those in excess of 2000 feet, are considered questionable, and the local negative embayment flanking the southern side of the ridge may be excessively, perhaps even erroneously, expressed in the depth contours. However, the indications of deepening of the basement to the north and southwest of the ridge are believed to be representative of the general conditions existing here.

Elsewhere in the northern and central portions of the area, the basement is indicated to have a gently rolling surface, with broad changes in relief on the order of 500 to 700 feet. A major north-south trending fault is observed to pass through this region, evidenced by a well-defined, linear disruption of minor magnetic trends and alignment of low amplitude anomalies.

In the southern portion of the area, the depths indicate the presence of a local, northwesterly-trending

trough in the southeastern corner which lies between two zones of positive relief. The maximum depth in this trough is 3800 feet below sea level although this is thought to be excessive. Approximately 2000 feet below sea level is considered to be a more representative value. The eastern and western sides of this trough rise sharply upward at a slope of about twelve per cent. It is possible that some faulting is present along the sides, particularly to the east along the very linear, elongate anomaly present there.

Following a positive arching in the south-center of the area, the basement slopes downward once again toward the southwestern corner, where two questionable depths in excess of two thousand feet below sea level were obtained.

A number of local areas, characterized by minor magnetic anomalies on the order of less than ten gamma in amplitude, are indicated as zones of possible minor basement relief and/or sedimentary structure.

CONCLUSIONS

Study of the magnetic survey data indicates that the basement complex beneath both areas is comparatively shallow. The average depth in the Keller Lake Area is between 1000 and 1500 feet below sea level, while at Rae Lake it is between 500 and 1000 feet below sea level. In view of these findings, these areas are considered to hold little promise as petroleum prospects, although there is always the possibility of the existence of some unusual geological circumstances not readily apparent from the present data which could change this view.

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Geophysicst

February 26, 1969

Philadelphia, Pennsylvania

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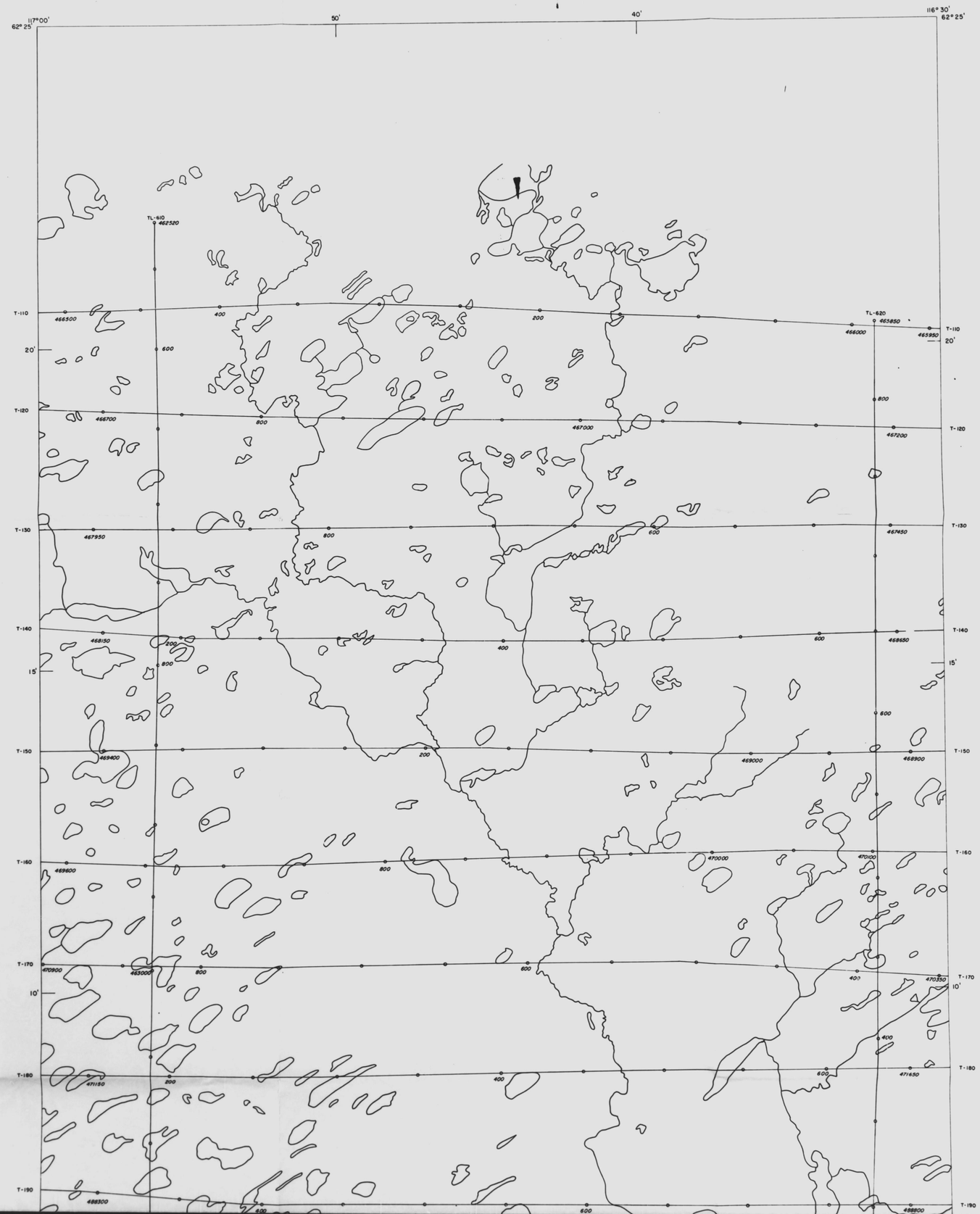
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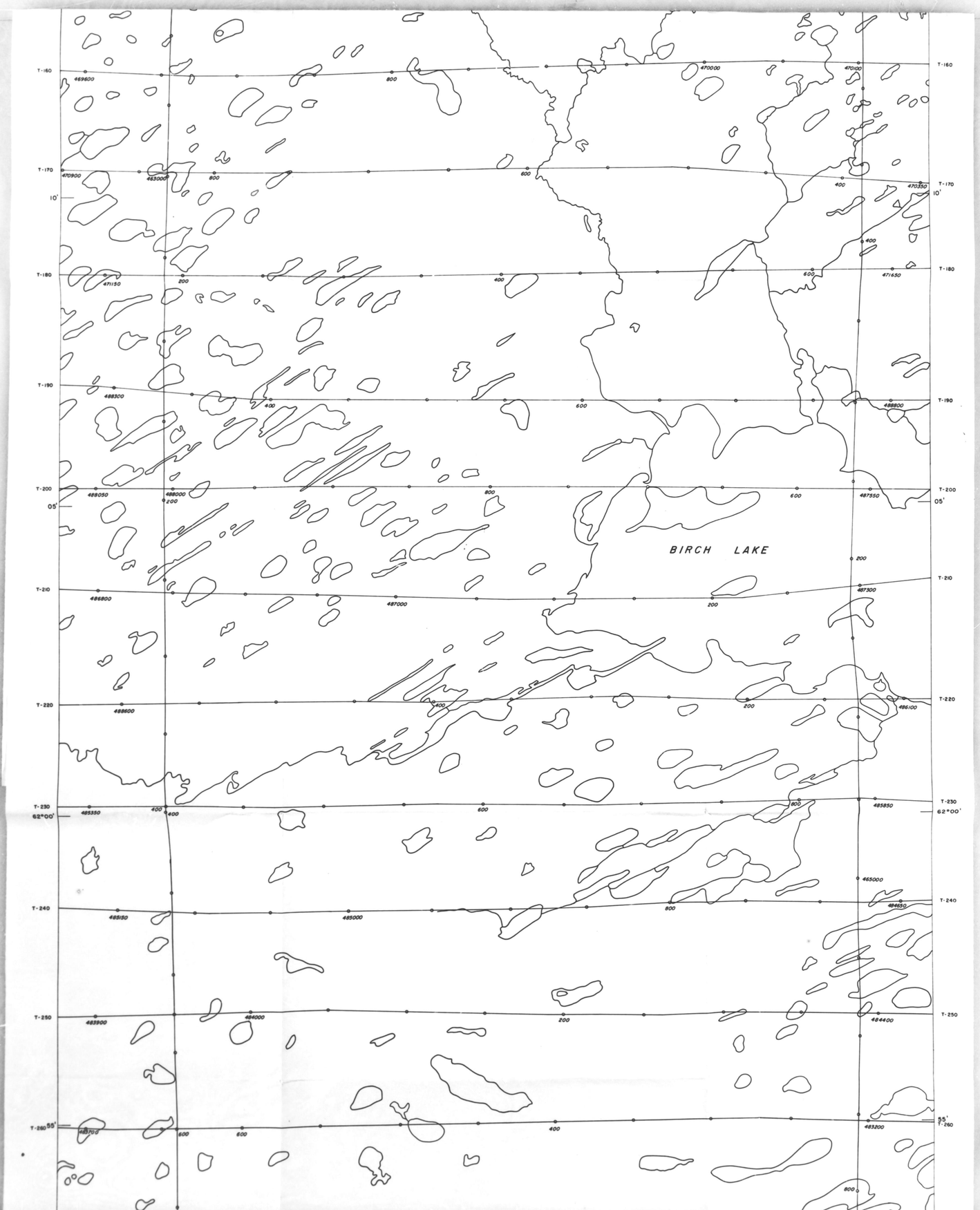
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117°00'
50'
40'
116° 30'
62° 25'
62° 25'
TL-610
462520
TL-620
465850
465950
T-110
466500
400
200
466000
T-110
20'
600
800
T-120
466700
800
467000
467200
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T-130
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T-170
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600
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10'
400
T-180
471150
200
400
600
471650
T-180
T-190
488300
600
488800
T-190

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T-160
T-170
T-180
T-190
T-200
T-210
T-220
T-230
T-240
T-250
T-260
10'
05'
62°00'
55'
469600
800
470000
470100
470900
453000
600
400
470350
471150
200
471650
488300
488800
489050
488000
487550
BIRCH LAKE
487300
486800
487000
486600
486100
485350
485850
485150
485000
465000
484650
483900
484000
484400
483700
483200

2f

T-220 488600 400 700 486100 T-220

T-230 62°00' 485350 400 400 600 800 485850 T-230 62°00'

465000

T-240 485150 485000 800 484650 T-240

T-250 483900 484000 200 484400 T-250

T-260 55' 483700 600 600 400 483200 55' T-260

800

T-270 482450 600 800 482950 T-270

T-280 482250 200 482000 800 481750 T-280

464650

T-290 50' 463950 464000 463800 200 400 464450 50' T-290

463820 464620

TL-610 TL-620

61°45' 117°00' 50' 40' 61°45' 116°30'

AIRBORNE MAGNETOMETER SURVEY

RAE LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

SCALE: 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

NORMAL VARIATION CORRECTION APPLIED

HORIZONTAL CONTROL ..... BASED ON 1:250,000 TOPOGRAPHICAL MAPS PUBLISHED BY D.E.M.R. OTTAWA

FLIGHT ALTITUDE ..... 2000 FEET A.S.L.
TRAVERSE INTERVAL ..... 2 MILES
CONTOUR INTERVAL ..... 2 GAMMA
BASE INTENSITY ..... ARBITRARY

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

CAS. 9908

3 of 3

OIL & GAS OPERATIONS UNIT
Oil and Mineral Division
MAR 24 1969
OTTAWA, CANADA
Dept. of Indian Affairs & Northern Development

INTERPRETATION REPORT
MAGNETOMETER/GRADIOMETER SURVEY
OF
RAE LAKE AND KELLER LAKE AREAS
NORTHWEST TERRITORIES, CANADA

TABLE OF CONTENTS

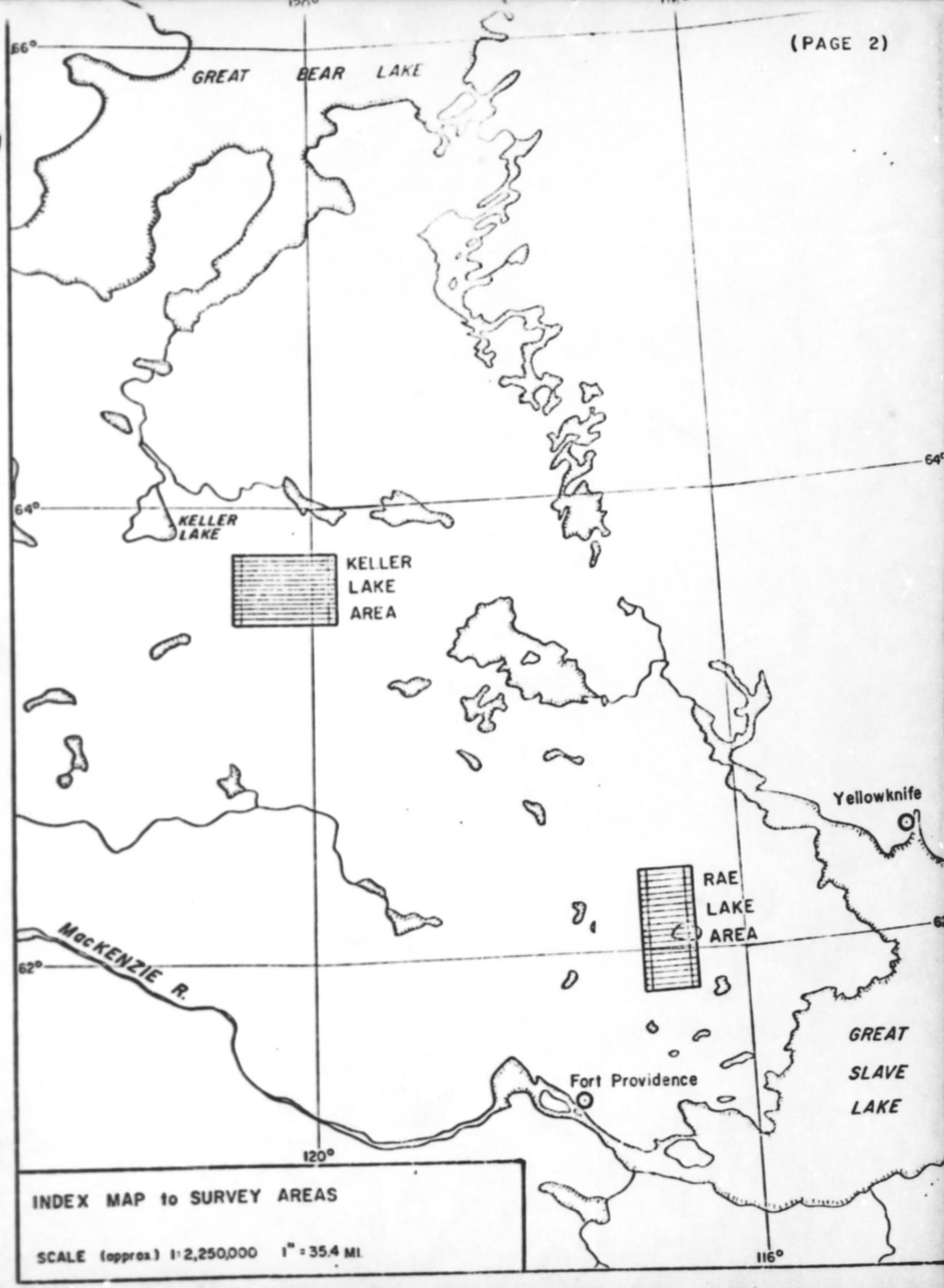
Subject	Page
Introduction	1
Statistics	4
Elements of the Earth's Magnetic Field	6
Interpretation Theory and Procedure	10
General Geology	19
Geophysical Interpretation	21
General	21
Keller Lake Area	22
Rae Lake Area	26
Conclusions	30
Bibliography	31

INTRODUCTION

On September 16 and 17, 1968, an airborne magnetometer/gradiometer survey was performed over two areas in northwestern Canada for Rayalta Petroleum Limited by Canadian Aero Service Limited. The two areas, designated as Rae Lake and Keller Lake, are located in the Northwest Territories in the region between Great Bear Lake and Great Slave Lake. The index map overleaf shows the approximate location and areal extent of the survey work.

The survey was performed using two alkali vapor magnetometers trailed from a DC-3 aircraft and separated vertically by 220 feet at the aircraft air speed of 155 miles per hour. The total magnetic field intensity was recorded from the measurement of the lower sensor, while the vertical magnetic gradient was recorded from the difference in total magnetic field intensity between the upper and lower sensors.

The survey aircraft was flown at a constant barometric altitude of 2000 feet above sea level over the Rae Lake Area, and 2600 feet above sea level over the Keller Lake Area. The altitude of the lower sensor was approximately 1720 feet and 2320 feet above sea level, respectively. The flight direction


66°
GREAT BEAR LAKE
64°
KELLER LAKE
KELLER LAKE AREA
RAE LAKE AREA
Yellowknife
MacKENZIE R.
62°
Fort Providence
GREAT SLAVE LAKE
120°
116°
INDEX MAP to SURVEY AREAS
SCALE (approx) 1:2,250,000 1" = 35.4 MI.

of the traverses was east-west in the case of both areas. The distance between adjacent parallel traverses was two miles.

Navigation for the survey was obtained with a Doppler navigation system and monitored by a 35 mm. strip-film camera. These two positioning devices were used in recovering the aircraft position in the compilation stages. The digital fiducial interval (distance between data points) was 152 feet, and this was controlled by the Doppler along-path computer. The data was obtained both in analog and digital form in the aircraft, and the chart speeds for the analog recording were set to record the data at 1:30,000 scale.

During the course of the survey, a Gulf fluxgate magnetometer was operated on the ground to monitor diurnal conditions. This instrument was set at a full-scale sensitivity of 250 gamma. Data were recorded at three inches per minute on 5" chart paper at the base station of Yellowknife.

Only the total magnetic field data were compiled in map form. The compilation is presented at a scale of 1:48,000 (one inch equals four thousand feet) on one map sheet for the Rae Lake area and two sheets for the Keller Lake area. The results of the geophysical interpretation discussed herein are shown superimposed on the isomagnetic contour maps. Details of the interpretation procedures are described in a following section.

STATISTICS

CLIENT.....Rayalta Petroleums Limited

CONTRACTOR.....Canadian Aero Service Limited

AREA DESIGNATION.....Rae Lake and Keller Lake

PROJECT REFERENCE NUMBER.....9519

COMMENCEMENT OF FLYING.....September 16, 1968

COMPLETION OF FLYING.....September 17, 1968

OPERATIONAL BASE.....Yellowknife, Northwest Terr.

SENSORS.....Two Alkali Vapor Magnetometers

MAGNETOMETER INSTALLATION.....Two trailing sensors with a separation of 220 feet, at 155 m.p.h. air speed.

Analog Recorder.....Mosely 10" Rectilinear Recorder

Analog Chart Scale.....Total Field: 200γ/10 Major Chart Divs.
Gradient: 5γ/10 Major Chart Divs.

Analog Chart Speed.....Doppler driven for a horizontal scale of 2.4" per nautical mile

Digital Recorder.....Magnetic Tape

Digital Recording Increment..Total Field: 1/50 gamma
Gradient: 1/10,000 gamma per 220 Ft.

ALTIMETERS.....Minneapolis Honeywell Radar Altimeter
Rosemont Barometric Altimeter

Analog Recording Scale.....0 - 5,000' Full Scale (Radar only)

Analog Chart Speed.....Doppler driven for a horizontal scale of 2.4" per nautical mile

Digital Recorder.....Magnetic Tape

STATISTICS (Cont.)

ALTIMETERS (Cont.)

Digital Recording Increments.....5.0 feet (Barometric only)

FLIGHT ALTITUDES.....	Rae Lake	Keller Lake
Aircraft.....	2000'	2600'
Lower Sensor.....	1720'	2320'

FIDUCIAL INTERVAL (Doppler computed).....Index Fiducials - 1520'
Digital Fiducials - 152'

GROUND MONITOR.....Gulf Fluxgate Magnetometer

Sensitivity.....250 gamma full scale

Chart Speed.....3 inches per minute

LINEAR MILEAGE.....			
	Rae Lake	430	miles
	Keller Lake	464	miles
	Total	894	miles

SQUARE MILEAGE.....			
	Rae Lake	570	square miles
	Keller Lake	730	square miles

FLIGHT LINE SPACING & DIRECTION:

Traverses.....E-W at 2 mile interval

Tie Lines.....N-S at a variable interval

NAVIGATIONAL AIDS.....Bendix Doppler

DIGITAL SYSTEM.....An incremental digital recording of magnetometer output, gradiometer, fiducial numbers, time, Doppler cross track and altitude deviations

MAP PRESENTATION SCALE.....1:48,000

TOTAL FIELD INTENSITY.....59,500 gamma to 60,000 gamma

MAGNETIC INCLINATION....81°N **MAGNETIC DECLINATION**...34°E & 37°E

THE EARTH'S MAGNETIC FIELD

A magnetic field, such as that of the earth, is vectorial in nature, since at any point it is characterized by magnitude and direction. On the earth's surface this vector field is conventionally described by its intensity and by two angular elements defining its direction.

The unit of intensity by which the earth's field is measured is the gamma (γ), which is equal to 1×10^{-5} oersted. The oersted, the c.g.s. standard of magnetic intensity, is by definition the intensity extant at a point one centimeter from a unit magnetic pole. The direction of the earth's field is defined by its declination, the horizontal angle between the intensity vector and geographic north, and by its inclination, the vertical angle between the vector and the tangent to the earth's surface.

The field on the earth's surface resembles in its gross aspects the field distribution that would result were it caused by a relatively short bar magnet located in the center of the earth and inclined about twenty degrees to the geographic polar axis. Therefore, a magnetic equator exists in the tropics, inclined about twenty degrees to the geographic equator, which passes through Peru, Bolivia and Brazil in

South America; Sierra Leone, Nigeria, Sudan and Ethiopia in Africa; and Ceylon, Thailand and the Philippines in the Orient. Along this line, the magnetic inclination is zero; that is, the intensity vector is horizontal with respect to the earth's surface. The magnetic poles, the points on the surface at which the intensity vector is perpendicular to the earth's surface, are located at the north end of Prince of Wales Island, Canada (the north magnetic pole) and on the coast of the Australian-claimed sector of Antarctica (the south magnetic pole).

Using the bar magnet approximation, the total intensity of the earth's magnetic field is defined at any point as:

$$T=M/r^3 \ (1 + 3 \sin^2 \phi)^{\frac{1}{2}}$$

Where:

T = intensity of the earth's total field

M = earth's magnetic moment

ϕ = magnetic latitude

The magnetic latitude, ϕ, is related to the magnetic inclination, i, as follows:

$$\phi = \tan^{-1} (\tfrac{1}{2} \tan i)$$

The bar magnet expression indicates that the intensity at the magnetic poles is double that at the magnetic

equator. This is in agreement with field observation; the general intensity at the poles is about seventy thousand gamma, and along the magnetic equator it is about thirty-five thousand gamma. The transition from equator to pole is gradual and systematic in both direction and intensity.

The earth's surface field would presumably follow the bar magnet distribution perfectly if the planet was perfectly homogeneous in composition and magnetic properties, or if it was composed of concentric shells of homogeneous composition and properties. However, the near-surface magnetic disturbances, mainly the rocks of the upper mantle, cause local distortions in the idealized field of the earth. These magnetic anomalies, manifesting geologic structures and rock units, are caused by variations in the concentration and distribution of the magnetic minerals, primarily magnetite. The relatively local magnetic disturbances are the diagnostic features in airborne magnetometer surveys. Their shape and intensity are determined by many factors. Of these factors, the regional inclination and intensity are of critical importance. The remaining factors are properties of the causative body itself; composition, shapes, size, orientation, etc.

The proportion and direction of remanence in the causative body, as compared to induced magnetization, is

another important factor in the determination of the characteristics of the magnetic anomaly. This, however, cannot be assessed without laboratory study of many oriented samples of the body causing an anomaly; therefore, induced conditions are normally assumed in airborne magnetometer exploration.

INTERPRETATION THEORY AND PROCEDURE

The advent of the high sensitivity nuclear precession types of airborne magnetometers and complementary digital data recording techniques has permitted the direct application of electronic computers to the problems of interpretation. Rigorous quantitative calculations previously considered too time consuming have now become feasible, significantly enhancing the interpretive possibilities of magnetic data.

Of the many paths of interpretation opened by the digital data-digital computer combinations, Aero employs principally the process of direct computation of the apparent causes of every interpretable non-linear event on the magnetic profile, a process we refer to generally as "deconvolution".

An approximation assumed in all airborne geophysical surveying is the equivalence of the variations of the scalar of the total field to the projection of the anomalous vector upon the total field vector. This approximation is adequate for all normal anomalies which may be encountered in petroleum exploration. A consequence of this assumption is that any anomaly may be synthesized by the straightforward numerical addition of the supposed component anomalies.

Our methods are an extension of the interpretation methods outlined by S. Werner in his paper "Interpretation of Magnetic Anomalies at Sheet-like Bodies", (Stockholm, 1953). Werner points out that in the simple case where observations are made in a level plane over level-bounded bodies whose strike is infinite and at right angle to the profile, an interpretation equation in the form:

$$a_o + a_1x + b_oF + b_1xF = x^2F$$

may be written. In this equation, a_o, a_1, b_o and b_1 are the parameters of the interpretation equation, X represents distance along profile, and F represents the total field at x. Each of these parameters involves one or more of the four physical unknowns of the situation: the magnetization parallel with the plane of the sheet; the magnetization perpendicular to the plane of the sheet; the distance from the observation point to that point which lies immediately above the edge of the sheet; and the depth of the upper edge of the sheet from the plane of observation.

There being four unknowns, simultaneous solution of four equations involving x and the corresponding F will determine the parametric function, and from them the physical attributes referred to above. In the simple case, the geometric solution is complete; and for purposes of exposition only a

simple case will be considered here, although the addition of other parameters and other equations at other observation points will permit extension of the solution to more general cases.

It should be pointed out that the above theory is valid for all semi-infinite, homogeneous, sheet-like bodies, whatever their strike or dip, as long as the width of the sheet is not greater than 2.5 times the depth to the top edge of the sheet. If such is not the case, however, the theory can be extended by the recognition that such a body--a "thick" sheet"--can be considered as being bounded by two interfaces.* It is interesting that the magnetic anomaly for a thin sheet is precisely the derivative of the magnetic anomaly for a similarly positioned interface. Thus, by performing a "deconvolution" on both the total field and the horizontal (or vertical) derivative of the total field, we are able to identify and calculate the pertinent characteristics of thick sheets and individual interfaces, as well as thin sheets.

Our observation of total field having been made at equal linear intervals along the profile line, the computer

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*All "thin sheets" are bounded by two interfaces, but the interfaces are too close together for their individual anomalies to be distinguishable from one another--the combination of the two results in a single thin sheet anomaly.

now examines four successive equally spaced points and solves the set of linear equations for the physical parameters of interest at the position of the indicated anomalous body. The entire sequence of points is now advanced by one unit and the examination is repeated. If a succession of such examinations consistently indicates a source for the anomaly being observed, and if the indications (checked one to another) are themselves consistent, then the computer will indicate the apparent depth and along-profile coordinate positions of events as seen from each successive set of data points. These sets of coordinate positions of events are then recorded for subsequent plotting to scale by the CalComp plotter.

Since the sensitivity of the four point array to the detection of an anomalous source will be strongly related to the observational distance subtended by the array, the computation described above is repeated, first with observation points separated at an interval of three observation units, (the observed points, in our general practice, are 304 feet apart) and then with successive points separated at an interval of nine observation units, and then again at an observation interval of twelve units. In this manner, suitable "sensitivity" to events over a considerable depth beneath the observation plane becomes possible. These unit separations

are not invarient, and can be substituted for other unit separations in combination with various filter parameters to more precisely define specific depth bands.

Due to the fact that no empirical data can exactly match the signature of a theoretical model, the depth and position coordinates which derive from the computational sequence are not quite identical from one observational set to the next; and as a consequence, certain distinctive groupings of indicated points will occur for many of the anomalies. Since the richness of the data production offered by the method is so great that hundreds of such point groups appear, and since the groups will have continuity line to line, both of these aspects of the technique are used as weighting factors in evaluating depth points.

Concurrently with the solution of the parametric equations of the total field, the solution of the parameters for the first horizontal derivative of the total field and the vertical gradient (if it has been measured) are carried out, using identical parametric formulas. By this means additional depth solutions are obtained, from assumptions based on another source model. In particular, since the parametric formula for an interface, in the context of this discussion, is identical with the derivative either in Z or in X of the formula for a

thin sheet, the solutions have been extended--at the cost of some ambiguity, which must be solved from geologic considerations--to the cases of both dikes and interfaces. The power of the equations employed for direct interpretation of magnetic anomalies, permits solution of anomalies even when only parts of them are undisturbed by adjacent anomalies. Solutions are found from any four points in sequence, and these points need not be predetermined or be critical points or otherwise special points along the profile.

In the above discussion, only the simplest case is discussed. In our actual interpretations, we measure six parameters, involving six unknowns of the geological sources; and we interrelate groups of adjacent lines so that the error inherent in the depth calculations (which arise from the fact that in a real world, geologic strikes are neither infinite, nor do they always lie at right angles to the observation profiles) can be evaluated and corrected. As we refine our programs, we will add even more observation points and solve more of the pertinent equations affecting an interpretation.

Once this analysis has been completed there still remains the task of collating this data into a coherent set of geological circumstances. This phase of the interpretation can be conveniently separated into two general categories:

a) the qualitative recognition of structural and petrological units, and b) the quantitative assessment of anomalies or groups of anomalies with regard to depth, dimension, body parameters and susceptibility. Most of the latter has been accomplished when the computer analysis is complete.

In the delineation of rock units, the criteria are the frequency, extent, shape and orientation of the local anomalies; and the general intensity levels of the magnetically anomalous zones. These rock units, whether they be sedimentary units or crystalline basement units will not, in all cases, correspond to contacts mapped in the field on the basis of observed stratigraphic criteria. The reason for this is that stratigraphically different formations having similar magnetic mineral concentration and distribution will be expressed by similar magnetic patterns, while conversely, lithologic contrast within the same geologically mapped unit will give rise to contrasting magnetic patterns.

With few exceptions, the magnetic character of sedimentary rocks is very weak as compared to that of igneous and metamorphic rocks. Large local distortions in the natural magnetic field are, therefore, considered to arise primarily from the igneous and metamorphic basement. In general, the stronger the local magnetic relief and intensity, the greater

the proportion of magnetic minerals (chiefly magnetite) that is in the rock unit influencing the magnetic pattern. By further inference, the more likely it is to have a more basic composition. The smaller distortions of the field, in contrast, which are frequently present in equal or greater abundance than the larger features, are more likely to be caused by local basement relief or by magnetic effects in the sedimentary section.

Faults may be manifested magnetically by dislocations or disruptions in magnetic pattern or by persistent changes in pattern over long distances. Plugs, dikes and other igneous phenomena are inferred from the shape and intensities of the associated magnetic features. Recognition of such features is, to some extent, subjective in nature.

The dimensions, depth and susceptibility of the sources of the intense anomalies have been calculated, for those features that approximate two-dimensional conditions, by curve comparison against idealized tabular body standards. The susceptibility contrast is critically dependent on the assumed or interpreted width of the source body; if the true width is less than the assumed width, the susceptibility contrast will be greater than calculated, and vice versa. In

relating susceptibility contrast to percentage of magnetite by volume in excess of magnetite in the country rock, a figure of 0.3 c.g.s. units for the susceptibility of pure magnetite is commonly used.

All methods of quantitative study require assumptions of homogeneity and idealized shape. Inasmuch as rock bodies cannot be expected to satisfy these assumptions except under the most unusual of circumstances, quantitative conclusions should be regarded as estimates of magnitude rather than precise determinations.

GENERAL GEOLOGY

Both areas are located in the northern portion of the western Canada sedimentary basin near its eastern margin. In this region, the crystalline basement is in all essential respects a westward continuation of the Precambrian rocks exposed on the Canadian Shield a few miles to the east. The westward slope of the Precambrian complex beneath the overlying Paleozoic and Mesozoic sediments is very gentle, and only a relatively thin sedimentary layer would be expected to be present. The youngest formations exposed in the Rae Lake area are Lower to Middle Devonian in age, while in the Keller Lake area, formations of Cretaceous age comprise the principal outcrops. The Cretaceous section here is probably quite thin, however, as evidenced by the widespread occurrence of Lower Paleozoic rocks to the south and east less than ten miles away.

In general, the geological framework of the area does not appear favorable for the accumulation of petroleum. Experience gained in the exploration and development of petroleum reserves further south in the western Canada basin (Peace River region, etc.) has shown that a great thickness of section is not a primary requirement for oil accumulation in this region, although the

section there is considerably thicker than in the areas of the present survey.

GEOPHYSICAL INTERPRETATION

General

The depth and general configuration of the basement surface in the two areas, as shown on the accompanying interpretation maps, is based primarily on the computer techniques of analysis outlined earlier. In a number of cases, the analog records were analyzed by graphical methods as an approximate comparison with the computer-derived depths. The results of this comparative study show that there is a general agreement between the two methods in the case of the relatively shallow depths up to about one thousand feet below sea level. In the case of the deeper computer-derived depths, particularly those in excess of two thousand feet below sea level, the graphical solutions consistently indicate more shallow values. Since the derivation of these deeper depths involves several sets of mathematical filtering and operator spacings, as described earlier, it is difficult to precisely define the degree of validity of the computed values in many cases. It will be noticed, however, that many of the exceptionally deep depth estimates are followed by a question mark on the map, indicating their questionable nature. Moreover, most of these have not been completely contoured even though they

have influenced the general depth contour pattern.

Keller Lake Area

The magnetic pattern displayed in this area is moderately complex. The principal anomalies are rather broad and quite elongate in shape with a predominant east-west trend. This direction of trend presents a problem in obtaining estimates of depth, inasmuch as the traverse direction parallels most of the diagnostic magnetic gradients. Depth information in the central position of the area is particularly scanty for this reason, and those depths which were obtained may in many cases be excessively deep.

An abrupt departure from the general anomalous orientation is observed along the western margin of the area and again in the extreme northeastern corner. In these localities, the magnetic trends are essentially north-south. These changes in trend are accompanied by an increase in local magnetic relief, particularly in the case of the zone along the western margin of the area where the magnetic intensity attains a maximum of one hundred seventy gamma. The partially-mapped anomaly in the northeastern corner has a maximum observable amplitude of one hundred twenty gamma.

In contrast to these localities of maximum relief, the local magnetic response throughout most of the area has a general range between fifty and one hundred gamma.

The elongate east-west magnetic trends comprising the major portion of the area are interpreted as the expressions of elongate, tabular shaped units of rock which are relatively more basic in composition than their surroundings. Two principal zones are observed, one trending east-west to northwest across the northern half of the area and the other trending northwest-southeast across the western half. The zone in the north is relatively continuous, although minor offsets in the trend are present which are interpreted as evidence of faulting in a northerly to northeasterly direction. The zone in the west is not so well defined and, moreover, is severely broken up by at least two large offsets in the anomalous trend. These offsets are interpreted as faults, although with some reservations since the apparent horizontal displacement of each is indicated to be as much as three miles.

In the south-center of the area near the southern boundary, a broad, twin-peaked positive anomaly is present which has a northeast-southwest orientation. This feature

is interpreted as two closely spaced, tabular bodies of relatively basic rock which may represent a repetition of section caused by a relatively tight, local fold in the basement formations. The abrubt termination of the anomaly to the northeast lends support to this interpretation, although the nose of the structure is not expressed in the magnetic contours. A southeasterly-trending fault interpreted as passing through this locality adds to its structural complexity. Although this zone extends beyond the southern boundary of the area, it appears to have some relation to the extensive, southeastward-trending zone discussed above. Possibly the two features describe opposite limbs of a broad fold or flexure of the basement units.

The two zones of predominantly north-south magnetic trends in the southwest and northeast portions of the area are interpreted as the expression of basement rock units of relatively basic composition. Since the zones are only partially mapped by the survey coverage, it is not possible to determine the extent and configuration of these causative units. An examination of the mapped portions, however, suggests that the unit in the northeast may be relatively local, and possibly be structurally related to the elongate,

east-west trend located immediately to the south. The zone in the west, in contrast, is apparently much larger in areal extent, and may represent a major lithologic and structural discontinuity in the basement complex.

Estimates of the depth to basement in the area range from sea level to 3000 feet below sea level. The basement surface revealed by the depths is erosional in nature, as evidenced by the poor degree of correlation between its present configuration and the ancient structural elements defined by the magnetic pattern.

Two broad areas of positive basement relief are present in the central portion of the area, one in the north and the other in the south. Both have a general east-west trend. They are separated by a broad, elongate, east-west trough which passes through the center of the area and terminates against an interpreted fault zone bordering the north-south magnetic discontinuity described above. A maximum depth of 3100 feet below sea level is indicated near the western terminus of this trough. The western side of the area exhibits a gradual rise of the basement surface to the west. Minimum depths of 300 feet below sea level are estimated along the western boundary.

A second zone of negative basement relief, more

localized than the central trough, is suggested in the northwestern portion of the area by a series of depth estimates in excess of 2000 feet below sea level. A possible maximum of 3000 feet was obtained on the eastern side of this depression, but its validity is questioned because of its position on the anomalous gradient as well as the small angle of incidence between the gradient and the traverse direction.

Three local areas of possible minor basement relief and/or sedimentary structure are outlined in the north, west and south-center of the survey block. Two of these are associated with relatively shallow depths, suggesting supra-basement structural sources.

Rae Lake Area

The magnetic contour pattern displayed in this area is considerably more complex than that of the Keller Lake region. The individual anomalies are much more localized, smaller in areal extent, and moreover, are substantially higher in intensity. The predominant magnetic trends are north-south to northwest-southeast, although local exceptions are prevalent throughout the region. These local divergent trends, which are generally oriented northeast-southwest to east-west, are for the most part interpreted as the manifestation of basement faults.

A large proportion of the magnetic response observed in the area is comprised of rather extensive zones of relatively high amplitude anomalies. The local magnetic relief in these zones ranges from about 150 to 300 gamma, although significantly higher amplitudes are attained in the north-center and southeastern portions of the area, where anomalies with relief in excess of 500 gamma are observed. These zones are interpreted as the expression of changes in composition of the basement rocks from relatively acidic to relatively more basic varieties. The complex configurations of the rock units thus defined suggest that the basement is quite complicated structurally. Few of these Precambrian structures, however, appear to be expressed in the present basement surface which is principally erosional in nature.

The basement surface, as determined from depth estimates to the sources of the magnetic anomalies displayed, is somewhat shallower here than in the Keller Lake area. The basement is indicated to be very near the present topographic surface in the vicinity of Birch Lake and again in the northwestern corner of the area. The Birch Lake high is a rather broad, gently sloping feature forming a portion

of an extensive positive region which underlies most of the central and eastern parts of the area. The zone of positive relief in the northwest is apparently more localized. It comprises an elongate, east-west trending basement ridge which drops off rapidly to the north and south to depths in excess of 1500 feet below sea level. Many of these depths, particularly those in excess of 2000 feet, are considered questionable, and the local negative embayment flanking the southern side of the ridge may be excessively, perhaps even erroneously, expressed in the depth contours. However, the indications of deepening of the basement to the north and southwest of the ridge are believed to be representative of the general conditions existing here.

Elsewhere in the northern and central portions of the area, the basement is indicated to have a gently rolling surface, with broad changes in relief on the order of 500 to 700 feet. A major north-south trending fault is observed to pass through this region, evidenced by a well-defined, linear disruption of minor magnetic trends and alignment of low amplitude anomalies.

In the southern portion of the area, the depths indicate the presence of a local, northwesterly-trending

trough in the southeastern corner which lies between two zones of positive relief. The maximum depth in this trough is 3800 feet below sea level although this is thought to be excessive. Approximately 2000 feet below sea level is considered to be a more representative value. The eastern and western sides of this trough rise sharply upward at a slope of about twelve per cent. It is possible that some faulting is present along the sides, particularly to the east along the very linear, elongate anomaly present there.

Following a positive arching in the south-center of the area, the basement slopes downward once again toward the southwestern corner, where two questionable depths in excess of two thousand feet below sea level were obtained.

A number of local areas, characterized by minor magnetic anomalies on the order of less than ten gamma in amplitude, are indicated as zones of possible minor basement relief and/or sedimentary structure.

CONCLUSIONS

Study of the magnetic survey data indicates that the basement complex beneath both areas is comparatively shallow. The average depth in the Keller Lake Area is between 1000 and 1500 feet below sea level, while at Rae Lake it is between 500 and 1000 feet below sea level. In view of these findings, these areas are considered to hold little promise as petroleum prospects, although there is always the possibility of the existence of some unusual geological circumstances not readily apparent from the present data which could change this view.

Charles E. Curtis
Geophysicst

February 26, 1969

Philadelphia, Pennsylvania

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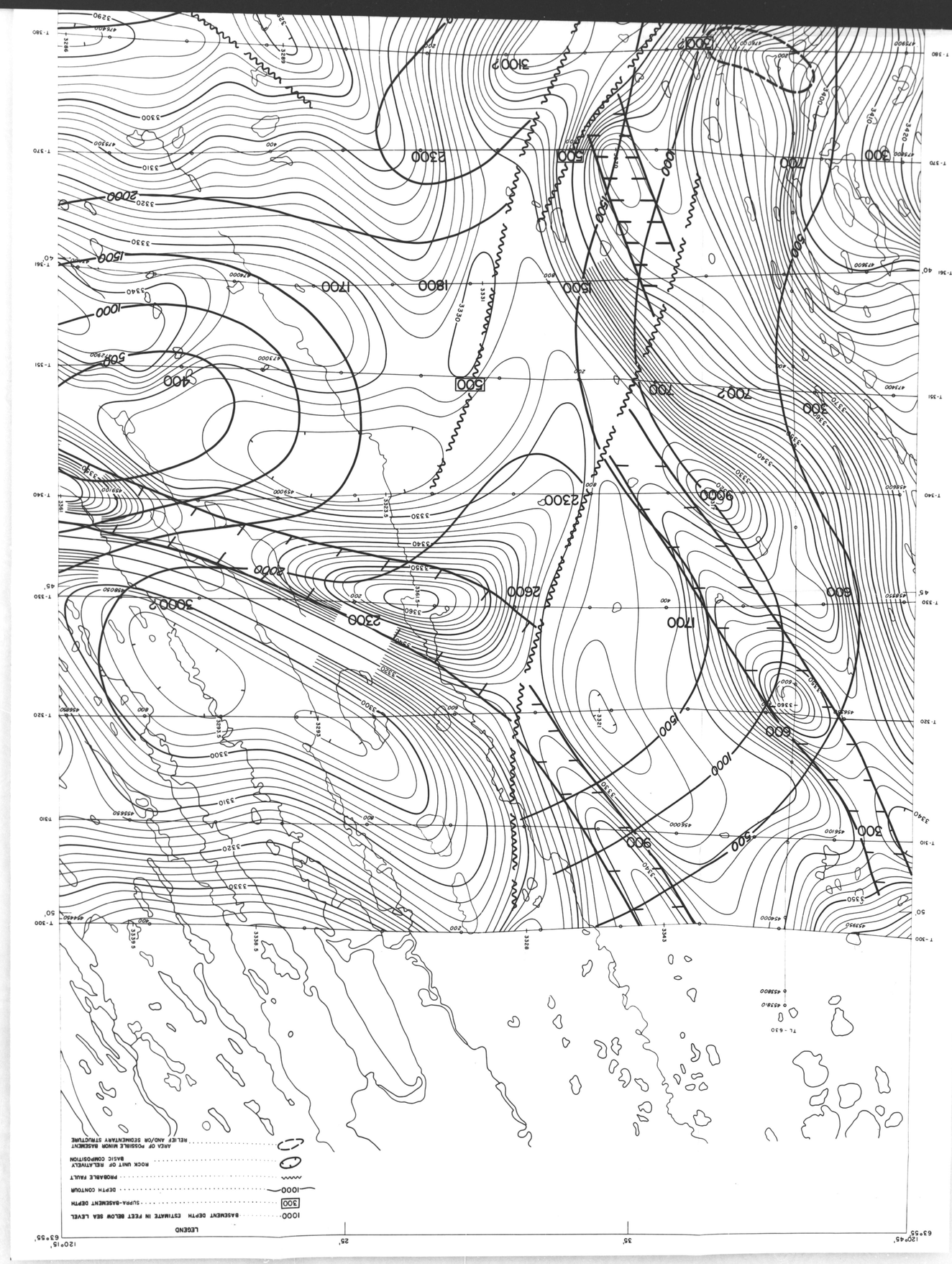
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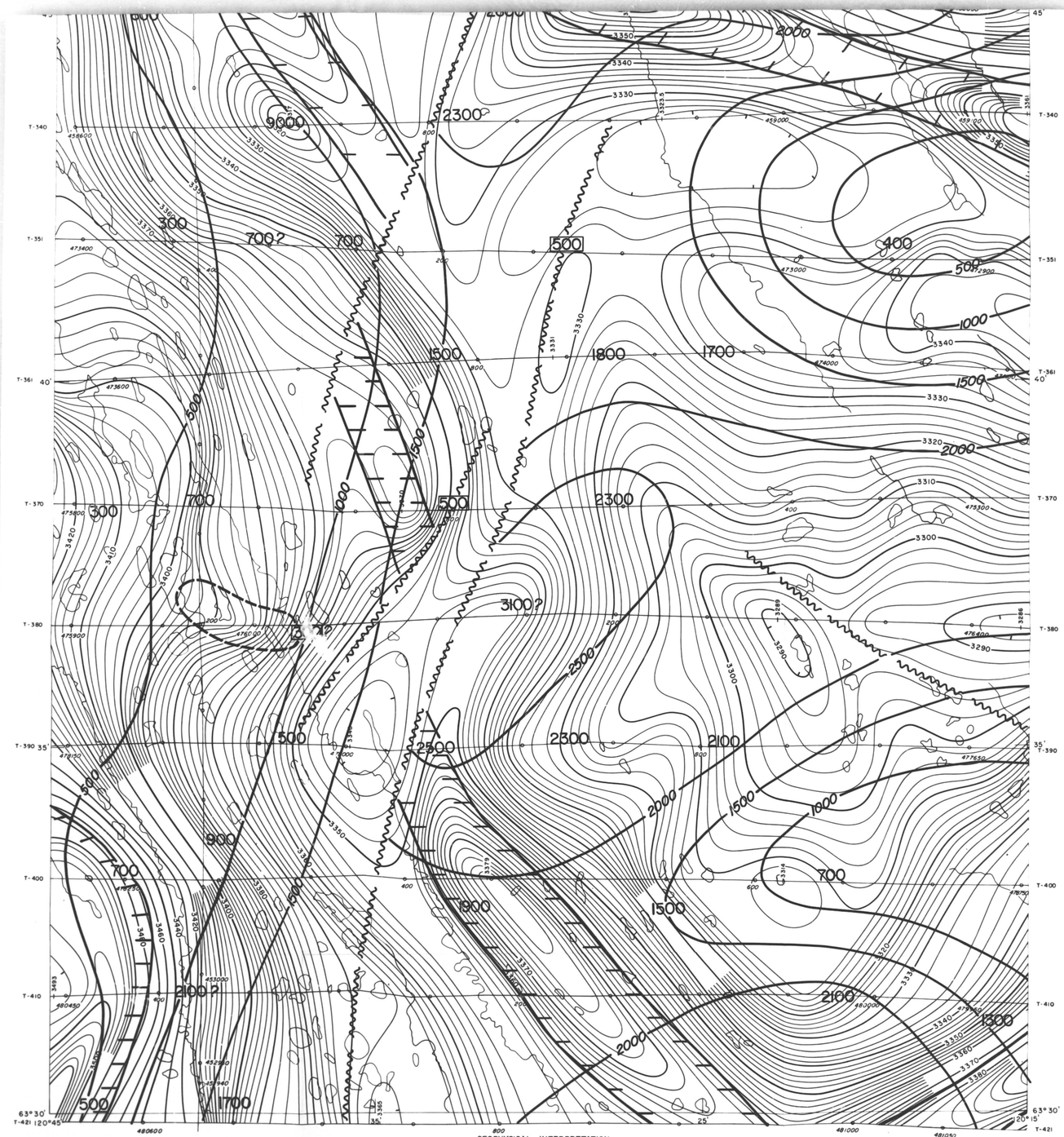
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LEGEND
1000 BASEMENT DEPTH ESTIMATE IN FEET BELOW SEA LEVEL
300 SUPRA-BASEMENT DEPTH
1000 DEPTH CONTOUR
PROBABLE FAULT
ROCK UNIT OF RELATIVELY BASIC COMPOSITION
AREA OF POSSIBLE MINOR BASEMENT RELIEF AND/OR SEDIMENTARY STRUCTURE
120°45'
63°55'
120°15'
63°55'
35'
25'
45'
50'
40'

1 of 2



GEOPHYSICAL INTERPRETATION
OF
AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

SCALE: 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

NORMAL VARIATION
CORRECTION APPLIED

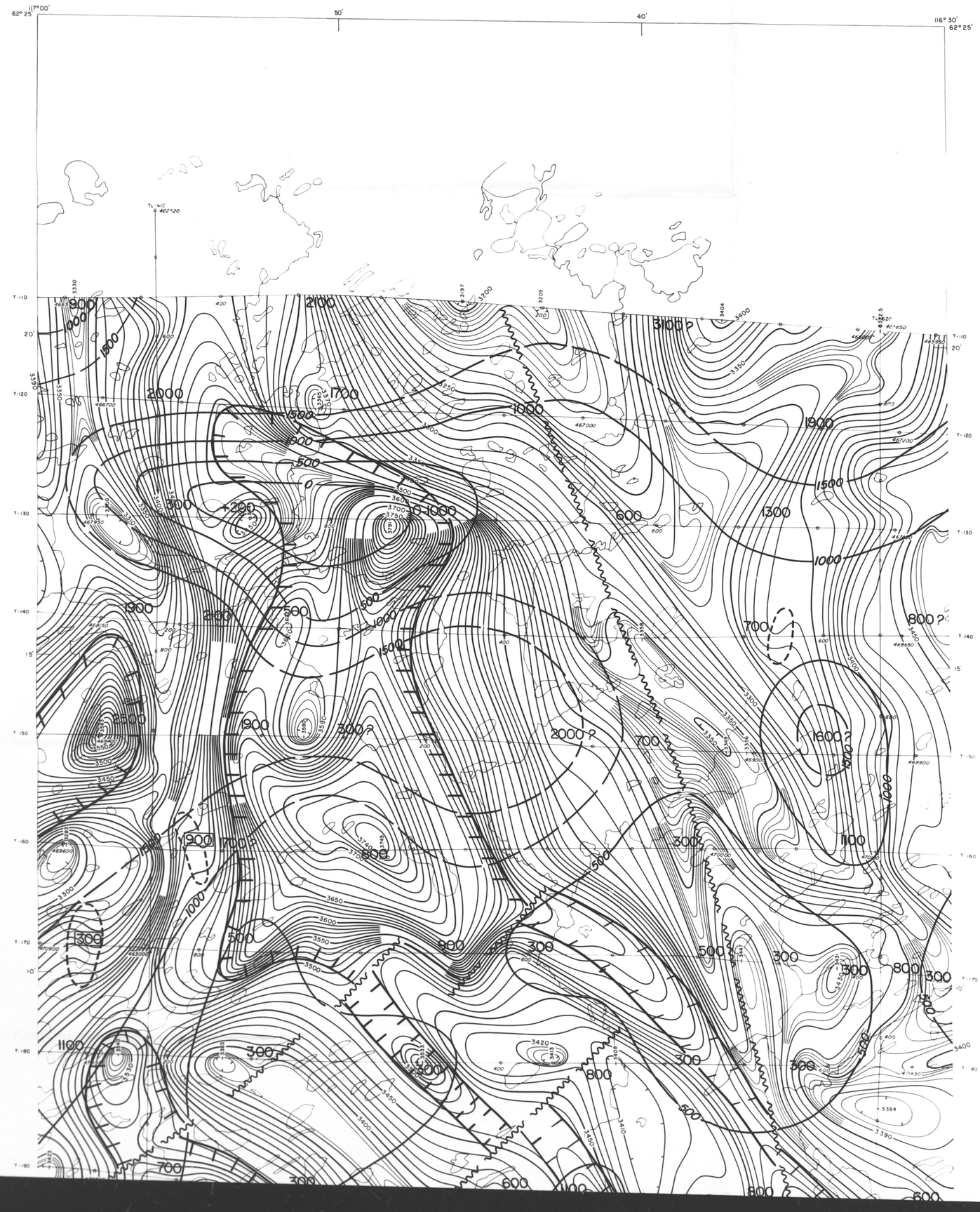
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1:250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA

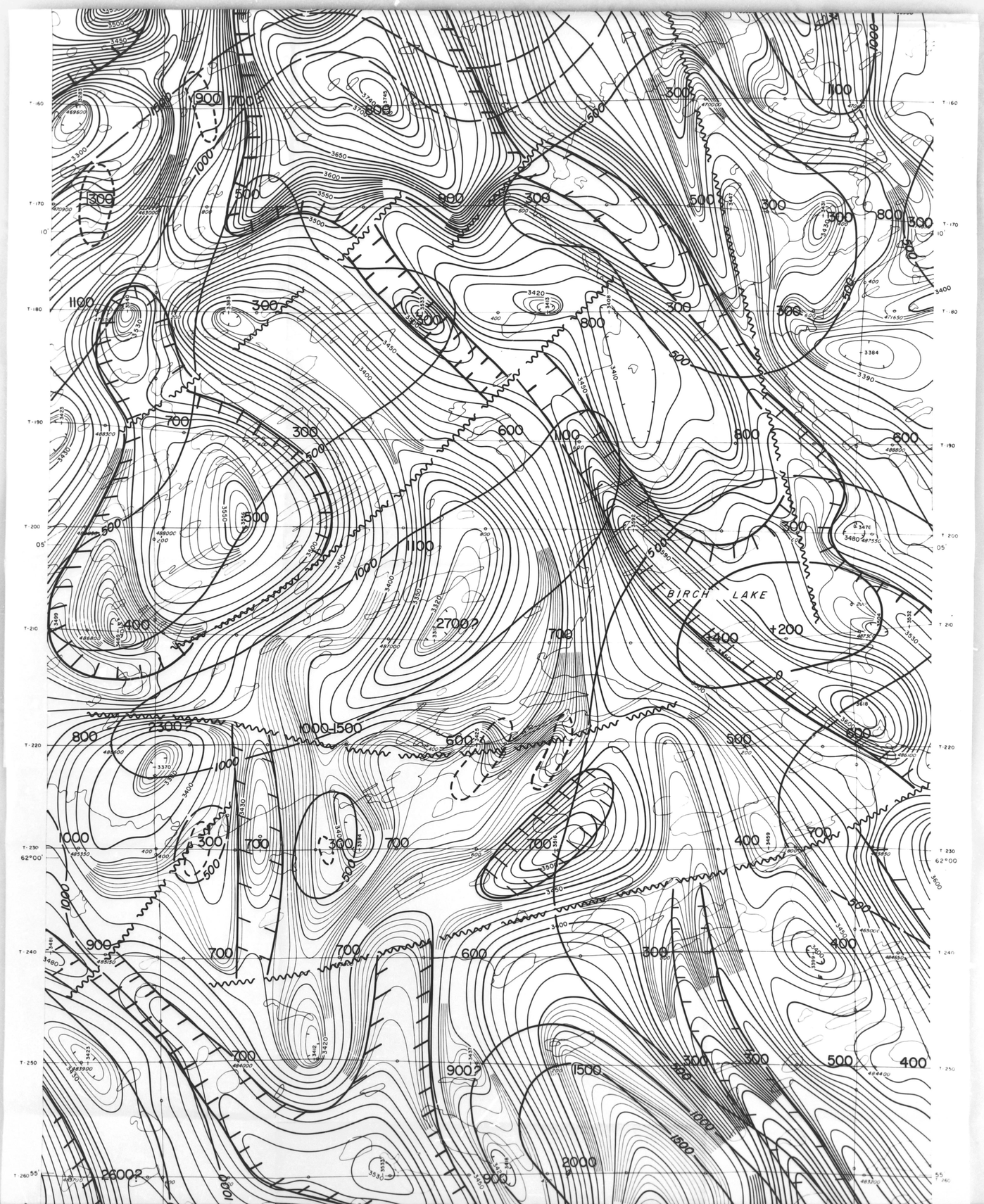
FLIGHT ALTITUDE ..... 2600 FEET A.S.L.
TRAVERSE INTERVAL ..... 2 MILES
CONTOUR INTERVAL ..... 2 GAMMA
BASE INTENSITY ..... ARBITRARY

1 2

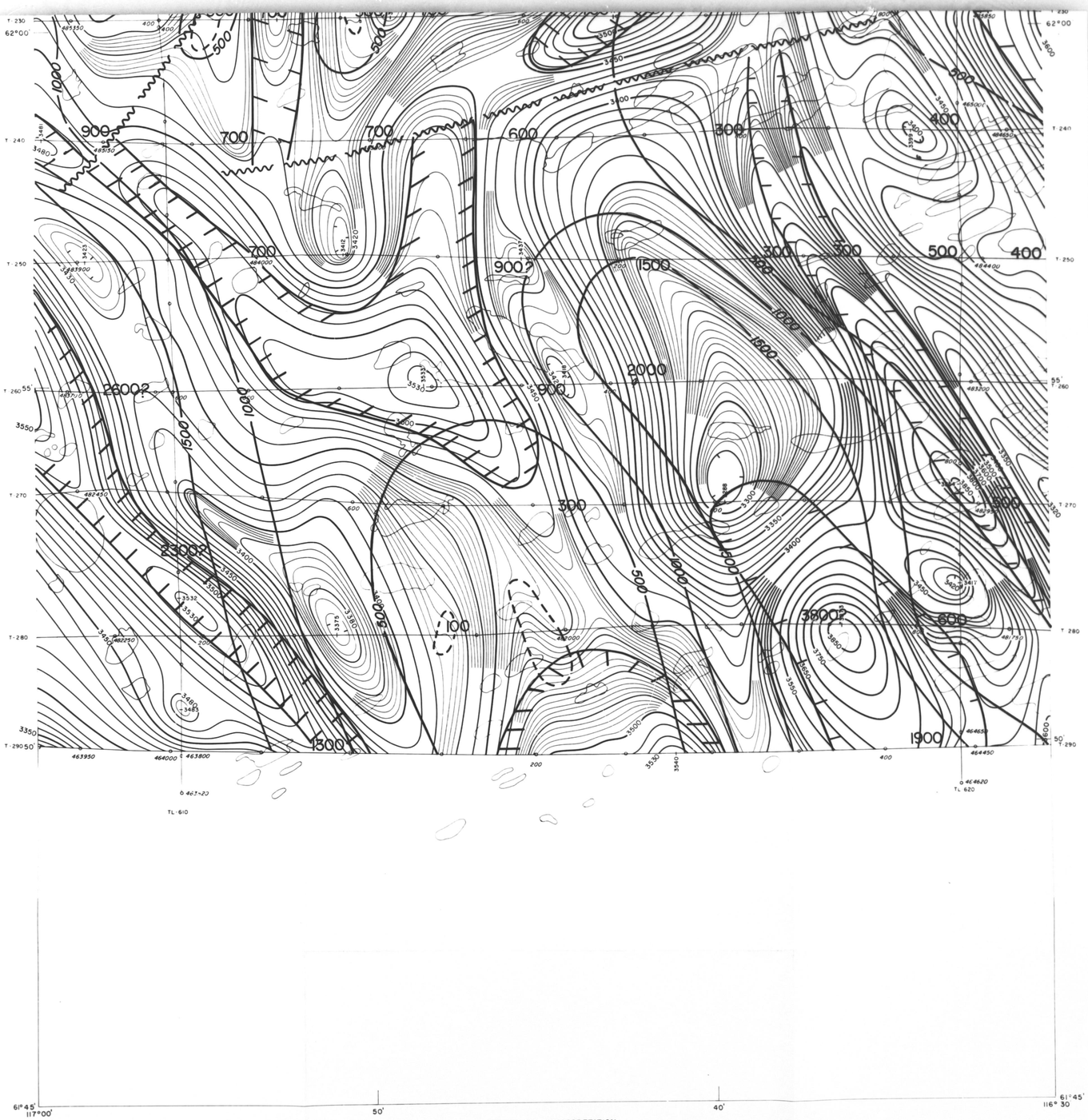
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

2 OF 2


117°00'
50'
40'
116° 30'
62° 25'
T-110
20'
T-120
T-130
T-140
15'
T-150
T-160
T-170
10'
T-180
T-190
TL-BIC
467420
466700
467000
467200
467650
468650
468900
469600
469950
470000
471650
463000
3330
3350
3197
3205
3404
3400
3380
3384
3390
3420
3410
3450
3500
3550
3600
3650
3700
3745
3750
3800
3850
3900
3950
4000
4050
4100
4150
4200
4250
4300
4350
4400
4450
4500
4550
4600
4650
4700
4750
4800
4850
4900
4950
5000
5050
5100
5150
5200
5250
5300
5350
5400
5450
5500
5550
5600
5650
5700


BIRCH LAKE
T-160
T-170
T-180
T-190
T-200
T-210
T-220
T-230
T-240
T-250
T-260
62°00'
10'
05'
55'

2



GEOPHYSICAL INTERPRETATION
OF
AIRBORNE MAGNETOMETER SURVEY
RAE LAKE AREA
NWT
RAYALTA PETROLEUMS LIMITED

SCALE 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

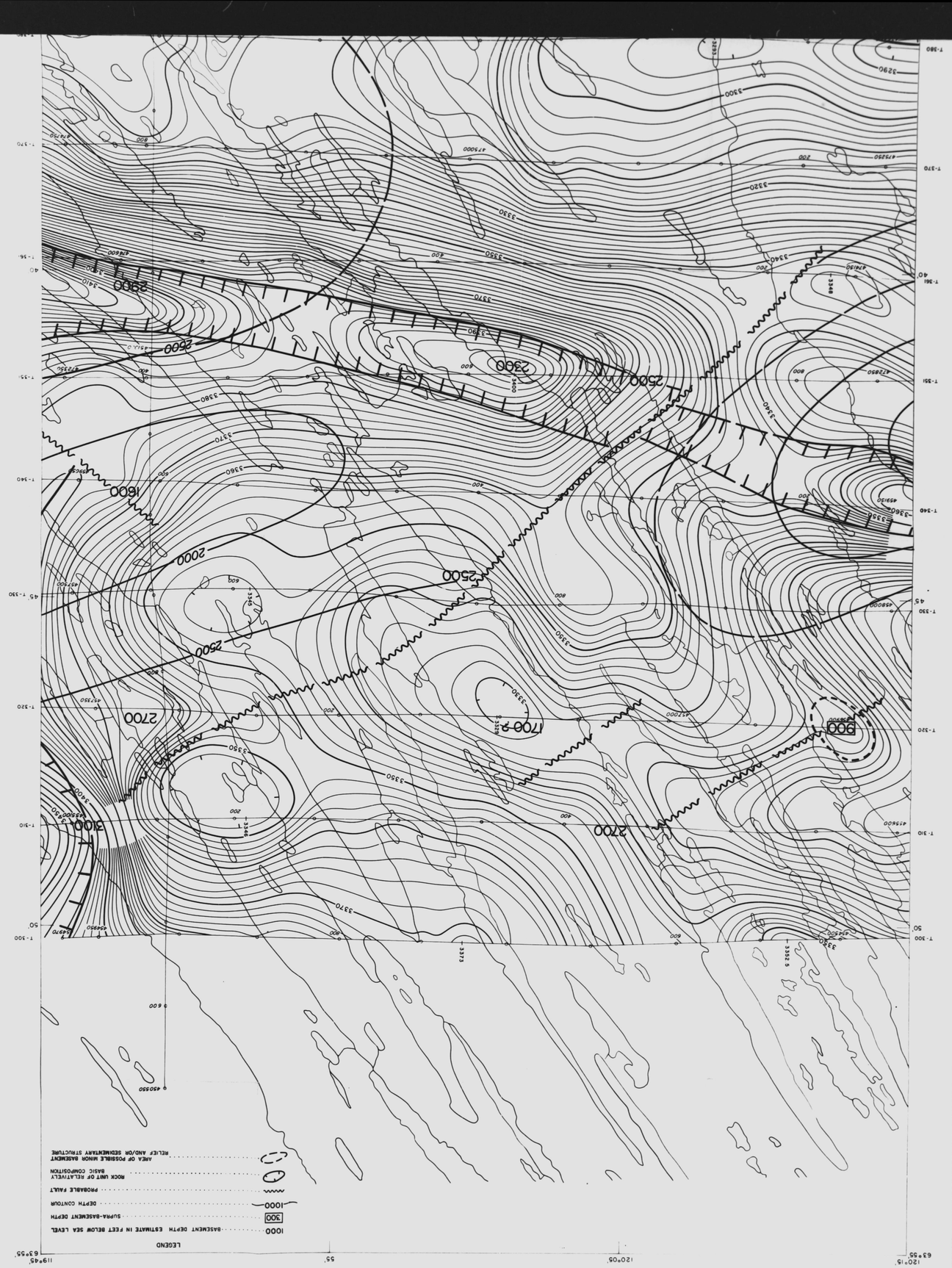
NORMAL VARIATION
CORRECTION APPLIED

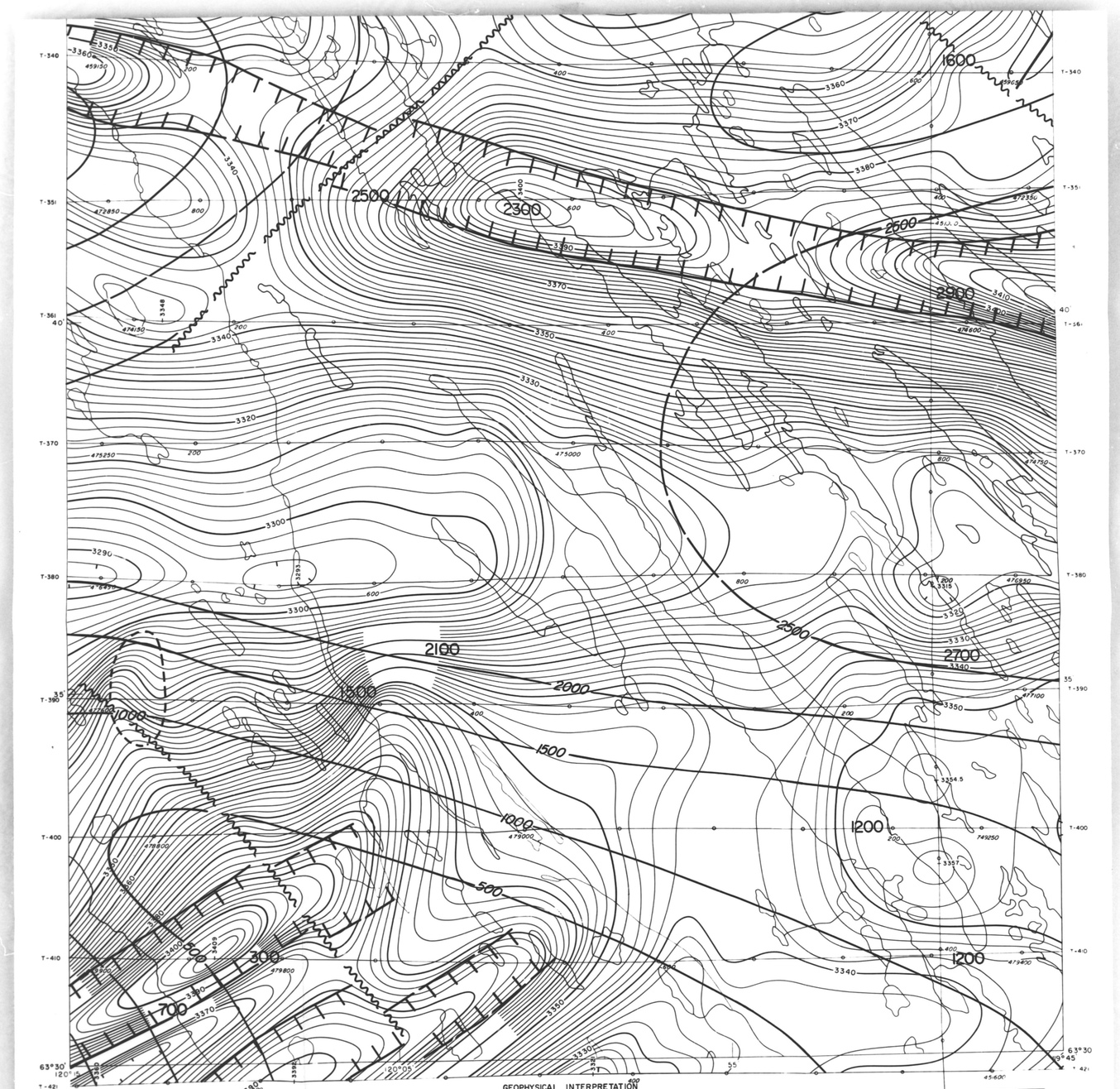
HORIZONTAL CONTROL BASED ON
1:250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA

FLIGHT ALTITUDE	2000 FEET A.S.L.
TRAVERSE INTERVAL	2 MILES
CONTOUR INTERVAL	2 GAMMA
BASE INTENSITY	ARBITRARY

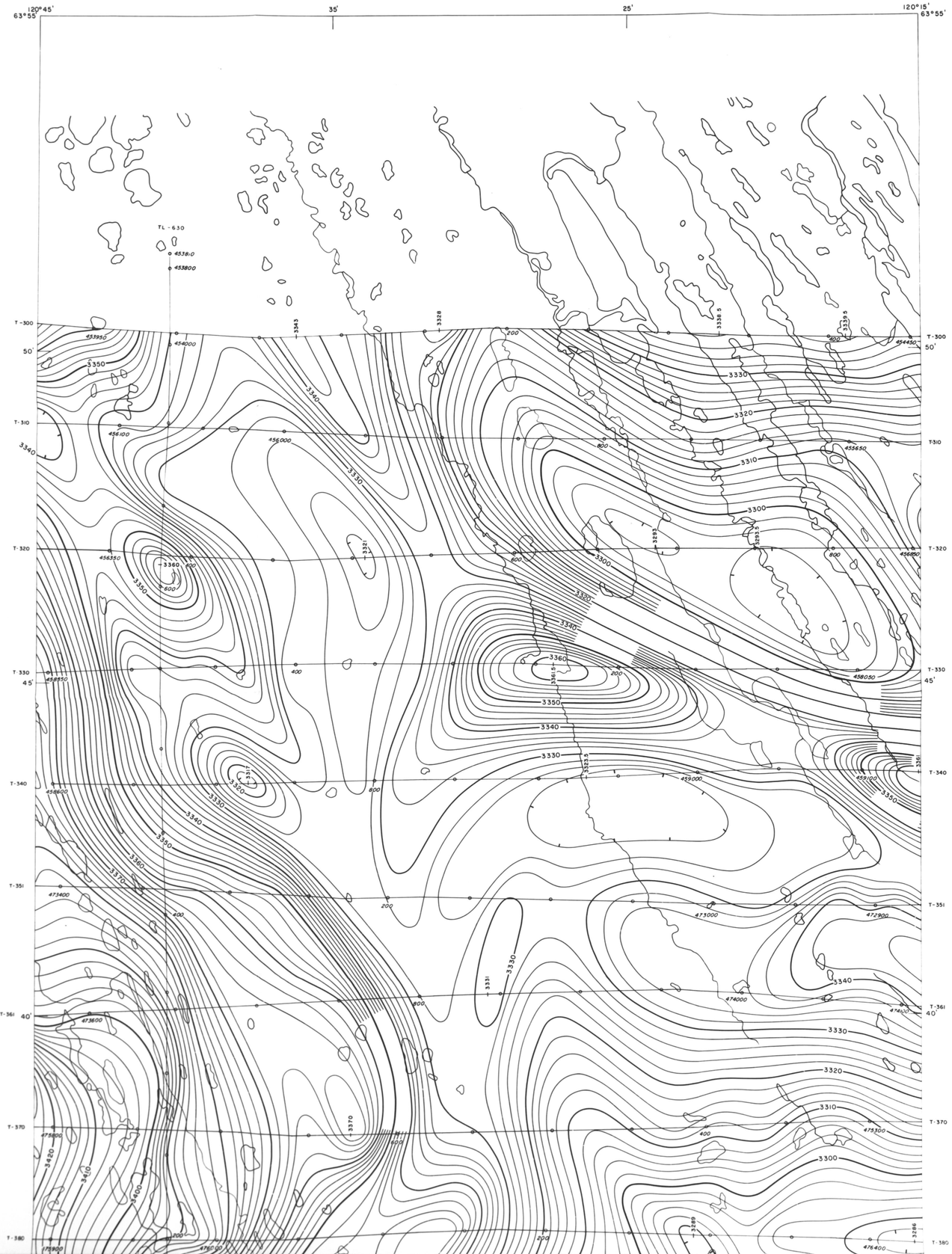
CANADIAN AERO SERVICE LIMITED
OTTAWA ONTARIO

CAS 1950B

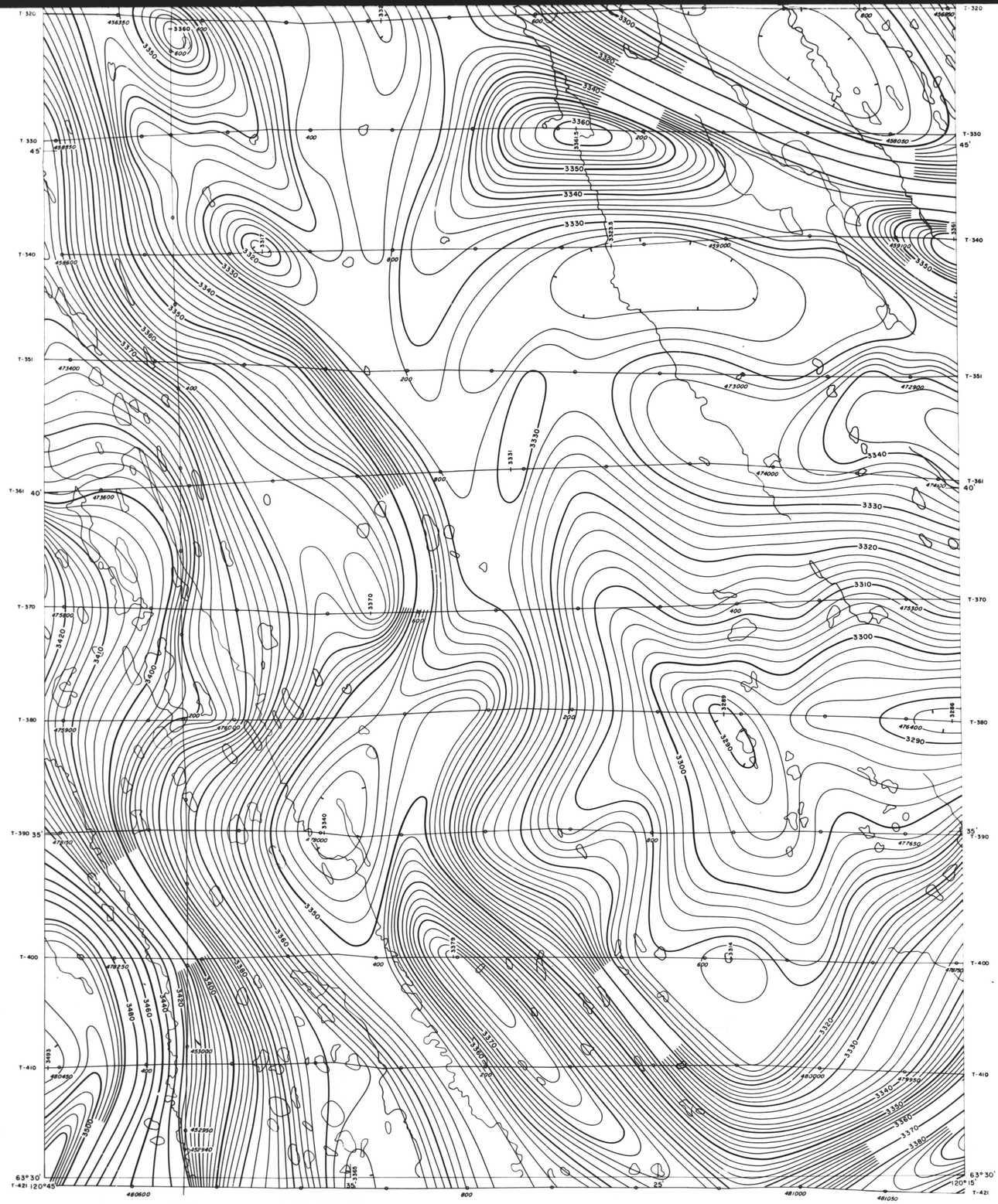

LEGEND
1000 BASEMENT DEPTH ESTIMATE IN FEET BELOW SEA LEVEL
300 SUPRA-BASEMENT DEPTH
1000 DEPTH CONTOUR
PROBABLE FAULT
ROCK UNIT OF RELATIVELY BASIC COMPOSITION
AREA OF POSSIBLE MINOR BASEMENT RELIEF AND/OR SEDIMENTARY STRUCTURE
2900
2600
2300
2500
1800
2000
2500
2700
1700
900
3100
FAULT
119°45'
63°55'
55'
120°05'
120°15'
63°55'


T-340
T-351
T-361
T-370
T-380
T-390
T-400
T-410
T-421
63°30'
120°
40
35
55
3360
3350
3340
3330
3320
3300
3290
3400
3380
3370
3310
3283
3354.5
3337
3410
1600
2500
2300
2900
2100
1500
1000
2000
1200
700
300
500
2700
459150
472850
474150
475250
475000
476600
479000
479800
479400
749250
477100
476850
451500
451600
481100
GEOPHYSICAL INTERPRETATION
OF
AIRBORNE MAGNETOMETER SURVEY
KELLER LAKE AREA
N.W.T.
RAYALTA PETROLEUMS LIMITED
SCALE 1 INCH TO 4000 FEET
4000 0 4000 8000 12000 FEET
NORMAL VARIATION
CORRECTION APPLIED
HORIZONTAL CONTROL BASED ON
1:250,000 TOPOGRAPHICAL MAPS PUBLISHED
BY D.E.M.R. OTTAWA
FLIGHT ALTITUDE 2600 FEET A.S.L.
TRAVERSE INTERVAL 2 MILES
CONTOUR INTERVAL 2 GAMMA
BASE INTENSITY ARBITRARY
1
2
CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

2 of 2


120°45'
63°55'
35'
25'
120°15'
63°55'
TL - 630
453810
453800
T-300
50'
453950
454000
3350
3340
3330
3320
3310
3300
3290
454450
T-310
456100
458000
453650
T-320
456350
3360
3350
3330
3321
3295
458050
T-330
45'
458550
3361
458600
459100
T-340
3350
3340
3330
3331
459000
T-351
473400
473000
472900
474000
T-361
40'
473600
474400
T-370
475600
3420
3410
3400
3370
475300
T-380
475900
476400
3286
3289

1 of



AIRBORNE MAGNETOMETER SURVEY

KELLER LAKE AREA

N.W.T.

RAYALTA PETROLEUMS LIMITED

SCALE: 1 INCH TO 4000 FEET

4000 0 4000 8000 12000 FEET

NORMAL VARIATION CORRECTION APPLIED

HORIZONTAL CONTROL ..... BASED ON 1:250,000 TOPOGRAPHICAL MAPS PUBLISHED BY D.E.M.R. OTTAWA

FLIGHT ALTITUDE ..... 2600 FEET A.S.L.
TRAVERSE INTERVAL ..... 2 MILES
CONTOUR INTERVAL ..... 2 GAMMA
BASE INTENSITY ..... ARBITRARY

1 2

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

CAS 9508

2 OF 2